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IMPROVING SOLDIER TRAINING: AN APTITUDE-TREATMENT INTERACTION A--ETC(U)
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THE UNITED STATES NAVAL WAR COLLEGE

DEPARTMENT OF THE NAVY
NAVAL WAR COLLEGE

PUBLISHED BY

THE NAVAL WAR COLLEGE

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LEVEL II

2

IMPROVING SOLDIER TRAINING: AN APTITUDE-TREATMENT INTERACTION APPROACH

BY

GARY W. BLOEDORN, LTCOL, U. S. ARMY

JUNE 1979

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UNCLASSIFIED
SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER

2. GOVT ACCESSION NO.

3. RECIPIENT'S CATALOG NUMBER

4. TITLE (and Subtitle)

6 Improving Soldier Training: An Aptitude-Treatment Interaction Approach.

5. TYPE OF REPORT & PERIOD COVERED

9 Final rept.,

6. PERFORMING ORG. REPORT NUMBER

7. AUTHOR(s)

10 LTCOL Gary W. Bloedorn

8. CONTRACT OR GRANT NUMBER(s)

9. PERFORMING ORGANIZATION NAME AND ADDRESS

Center for Advanced Research
Naval War College
Newport, Rhode Island 02840

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS

11. CONTROLLING OFFICE NAME AND ADDRESS

Center for Advanced Research
Naval War College
Newport, Rhode Island 02840

12. REPORT DATE

11 Jun[redacted]79

13. NUMBER OF PAGES

~~130 & Preface & Appendices~~

14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)

12 163

15. SECURITY CLASS. (of this report)

UNCLASSIFIED

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

[redacted] Unlimited

DISTRIBUTION STATEMENT A
Approved for public release;
Distribution Unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

Approved for public release; distribution unlimited

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

APTITUDE; TREATMENT; INTERACTION; DISORDINAL; ORDINAL; ANXIETY; ACHIEVEMENT; CRITERION; GENERAL INTELLIGENCE; CONSTRUCT; TAXONOMY; PARADIGM; INSTRUCTIONAL DEVELOPER; MODEL; PSYCHOLOGICAL; MEASUREMENT; ANALYSIS OF THE VARIANCE (ANOVA) AND REGRESSION ANALYSIS.

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

An analysis of the theoretical and methodological concepts available to and needed by the U.S. Army in developing soldier profiles in learning is presented within a context of the Army training, classification, and assignment systems. Statistical analysis techniques appropriate for Aptitude-Treatment Interaction research are discussed in general terms.

Current views of cognitive processes are examined as they relate to individual differences in learning. A coordinated approach to the study of -

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

aptitudes as information processing constructs is correlated with instructional development strategies to capitalize on individual aptitudes in learning. Recommendations are provided as to those aptitude variables that might be included in training effectiveness analyses on developing and fielded weapons systems and equipments and what steps can be followed to use such data for instructional purposes.

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Unlimited per Ms. Betty Tavares, Naval War College, Center for Advanced Research

EXECUTIVE SUMMARY

Introduction

This research report describes the structure and functioning of the U.S. Army's training and classification system for enlisted personnel. The report is cast within the context of an all volunteer force characterized by large numbers of poorly educated accessions who are required to operate and maintain weapons and equipment of ever increasing complexity. The central issue is an analysis of the theoretical and methodological tools available to the training developers to individualize instruction so as to capitalize on individual soldier aptitudes for learning. The report identifies promising individual aptitude constructs and teaching strategies appropriate for these aptitudes and suggests a research methodology for service use.

Background

The advent of the all-volunteer Army has coincided with declining standards in civilian education and rising sophistication of military hardware to produce a severe personnel-equipment performance gap that the present Army training system is ill-prepared to close. The Congress, the Government Accounting Office, the Department of Defense, and numerous independent research organizations have focused their attention in recent years on the costs and effectiveness of Army training programs. The resulting pressure has caused the

Army to make reductions in the time and money devoted to enlisted training at the very time vast sums are being spent to procure and deploy more complex systems. The result is that few of the Army's most modern and important systems are being operated to design capability. In effect, inadequately educated and trained soldiers are making it extremely difficult and costly for the Army to take full advantage of this technology. In effect the Army is in danger of buying less battlefield capability for more money. The Army recognizes this, and is working to reduce costs while simplifying equipment operating and maintenance designs. However, realistic and challenging training will continue to be necessary to ensure that individuals and units are prepared for the demands of combat. To that end, the Army's Training and Doctrine Command (TRADOC) has initiated a Training Effectiveness Analysis (TEA) program under the management of the TRADOC Systems Analysis Activity (TRASANA), to develop training programs and personnel classification procedures with the same degree of scientific rigor as is used to develop the weapon systems.

Purpose

The purpose of this research is to develop strategies to apply educational technology in the development of instructional techniques and methods to capitalize on individual soldier aptitudes. The report develops empirically derived

training models to allow training effectiveness analysts to use the complex variables that are present when trainers, trainees, critical tasks, materials, and training objectives come together as an instructional event.

Scope

The scope of the research includes the broad outlines of the Army's training and personnel classification system against a background of what is known about individual differences in learning. The research centers around the development of individual soldier profiles by investigating promising aptitude and motivation constructs and the relation of these constructs to task specific learning strategies designed to: (1) capitalize on individual aptitude strengths; (2) compensate for lack of aptitude or; (3) remedy educational deficiencies.

Current views of cognitive processes are examined as they relate to individual differences in learning. A coordinated approach to the study of aptitudes as information processing constructs is correlated with instructional development strategies. Recommendations are provided as to those aptitude variables that might be included in training effectiveness analyses on developing and fielded weapon systems and equipments and what steps can be followed to use such data for instructional purposes. Statistical analysis techniques appropriate for Aptitude-Treatment

Interaction research are discussed in general terms.

Aptitude-Treatment Interaction

One approach to the analysis of Instructional processes as they related to individuals is founded on the investigation of learner characteristics and educational treatments.

Aptitude-Treatment Interactions (ATI) entail much more than the differences in outcome of two alternative instructional treatments. Rather, ATI is oriented on the principle that learning is the result of neither individual differences nor specific instruction but rather the result of the interaction of the two to produce learning. Thus, if we tailor instruction to students of high aptitude for the task being taught, students of low aptitude do worse than if we were to teach them by methods for which they do have an aptitude. In other words, instructional techniques that may be well suited for one solider may be ill suited for others and may actually serve to degrade their learning.

The initial task for researchers is to develop a conceptual framework to describe individual learning traits Although the research literature does not now present a firm consensus as to the utility of these individual learner traits, it is rich in the formulation of testable treatments, and does identify certain combinations of aptitudes that show promise for predicting individual learner performance

as a result of specific instructional treatments. These aptitude variables include: (1) General mental abilities measured by standard tests on word knowledge, arithmetic and numerical skills, specific spatial abilities and past academic achievement scores; (2) cognitive styles (patterns of information processing) such as conceptual level and field-dependence are measured by tests desig ed to quantify a person's ability to conceptualize and to analyze complex situations. Conceptual level is usually measured by essay and sentence completion tests, while field-dependence is determined by results of the embedded figures test in which people must detect simple geometrical figures contained within more complex figures. Variations include tests in which the subject is required to locate a true vertical position within a complex, separately tilted environment. Subjects who can locate a true vertical are said to be "field-independent". Those who cannot are said to be "field-dependent". Lastly, (3) aptitude variable composites are dependent on personality constructs derived from motivation characteristics such as need for achievement, and anxiety traits, both of which can either positively motivate, or interfere with learning **performance** depending on the type task and the instructional strategy (treatment) being used.

A Summary of the Literature

While no interactions are so well confirmed that they can be used as guides to instructional developers without

a great deal of additional research, a pattern has emerged suggesting that those aptitude constructs discussed above can be employed to tailor instruction by thinking explicitly about what is to be taught and to whom. The following general rules seem to apply:

- Measures of high general ability combined with field-independent cognitive style, high achievement thru independence, and low anxiety identity, individuals who tend to learn more rapidly, and to retain it longer if they are exposed to a learning strategy emphasizing self-directed instruction. Persons with this aptitude construct should be allowed to organize and manipulate concepts as opposed to learning task specific rules. These students are thought to perform better under conditions of intrinsic motivation, without performance feedback, as they need little externally provided structure.

- Individuals of low general ability, who seek achievement through conformity to rules, who are field-dependent and relatively high in anxiety are thought to perform best under conditions in which the instruction is broken into small steps and is highly structured with extensive practice and feedback. These learners are dependent on teacher or authority initiated structure and peer opinion and appear liable to become disciplinary problems if the instructional strategy is unstructured and includes self-directed study components.

Various combinations of aptitude, i.e. average mental ability, low or no desire for achievement, an average level of anxiety, can be found to be combined in individuals with either field-dependence, independence or high/low conceptual level. Each of these combinations constitutes a distinct aptitude construct which should be treated according to the specific task to be mastered. Treatment variables include emphasis on spatial presentations, visually dense presentations (sequenced from the simple to the complex) and the need for practice sessions following visual presentations.

The overall conclusion is that subjects should be clustered by aptitude construct and the instructional strategy employed should be specifically tailored to the task and the learner aptitudes. Concepts of AIT can, with additional research to more precisely focus and align aptitude with task and instructional strategy, improve the terminal performance and skill retention of every student.

A Research Methodology

Because additional research is necessary and because the Army is using the development of soldier learning styles within the overall concept of TEA, this research report concentrated on the emerging research methodology as it should logically be applied to the Army's needs. A research methodology that appears to have promise is one which takes the

aptitude constructs of general mental abilities, personality variables and cognitive style, adds a dimension of physical ability and the appropriate techniques of statistical analysis, and places them within an information processing model. The components of this model include the coordination of learning and abilities into a hierarchial arrangement wherein learning is conceived of as a process of cognition, production of data and evaluation of that data leading to a behavior. This process may be hierarchially arranged so that simple tasks are viewed as being mastered by less complex abilities and more complex tasks dealing with concept formation, principles, transformations and problem solving are viewed as being mastered by highly complex cognitive functions largely related to measures of general mental ability. Figure 7 in Chapter V, p.71 presents this hierarchy schematically.

The aptitude and learning hierarchy is best viewed from the perspective of a stimulus-response-response pattern wherein the researcher seeks to measure and identify the process occurring within an individual during learning. This may be accomplished through use of an information processing model which makes useable distinctions between short term memory (STM), intermediate term memory (ITM), and long term memory (STM) and assumed subroutines to detect,

analyze, and evaluate incoming data in order to recognize patterns of indivudal differences in information processing that are thought to be at the heart of observable differences in learning. Chapter V presents a complex analysis of these information processing variables and outlines a research model by which these differences can be related to the three instructional strategies (the preferential compensatory and remedial strategies introduced above).

A synthesis of these concepts is presented which allows the researcher to correlate the relationship between the aptitude constructs and the instructional treatments. The requirement to establish the validity of these constructs is acknowledged and an implementing strategy appropriate for use within the TEA process is provided.

An Implementing Strategy

A four phase approach to ATI testing is recommended.

- Phase I - consists of use of the Interservice Instructional Systems Development (ISD) model and the Armed Services Vocational Aptitude Battery to identify the tasks to be trained and the target population aptitude clusters. The development of initial instructional treatments and development of the combined S-R-R/information processing analysis models is also accomplished during Phase I.

- Phase II - this phase is devoted to refinement of the instructional strategies to better align them

with the aptitude clusters within target population. This will probably include refinement/development of needed aptitude tests for cognitive style, personality variables and special measures of general intelligence that are likely to be highly task specific, such as measures of perceptual speed, memory span, closure speed, and visual memory.

- Phase III - is the actual conduct of the research characterized by data collection using the combined S-R-R/information processing model and multiple regression analysis techniques to avoid masking the effects of individual differences which may occur if analysis of the variance tehcniques are used.

- Phase IV - is devoted to the refinement of data analysis and feedback into the instructional/aptitude development programs necessary to both improve individual instruction and to support improvement of the research methodology of TEA.

Conclusions

1. Conclusion. Individual differences in learning exist and become important upon situational demand. Instructional strategies should be developed to exploit individual differences to ensure the best training for each soldier within the reduced training resources available.

Recommendation. That TRASANA's TEA program be implemented as planned with TRASANA being the overall manager of ATI research as well as of the TEA program. Investigations should be integrated with ongoing instructional programs and should be started at SL2 task complexity.

2. Conclusion. Great strides have been made in Aptitude-Research Interaction research but much more needs to be accomplished before the results can be used by instructional developers in the field.

Recommendation. ATI research being conducted by TRASANA should be supplemented by the Army Research Institute (ARI) to develop and refine:

- Measures of general mental ability to include measures of perceptual speed, memory span, closure speed, and visual memory.

- Measures of personality variables with emphasis on measures of achievement motivation and trait anxiety. Basic research into the effects on learning of other personality variables such as self-confidence, need for affiliation, power, social approval and degree of dogmatism should be carried on separately from the basic TEA research program.

- Measures of cognitive style to include field-dependence and conceptual level.

3. Conclusion. The Army is correct in its assessment of the training problem as reflected in the Army training system and the evolving TEA system. However, the field of ATI research is incredibly complicated and dependent on successful long range research.

Recommendation. That the ATI aspects of TEA remain a research concept until developed to the degree that ATI results can be used by the instructional developer without disruption of ongoing Army training activities. This will take patience, money, people, and time. These resources should be provided as necessary and the specific, detailed procedures of tailoring instructional strategies to individuals should be implemented within the parameters of present ISD model when perfected.

PREFACE

This research was initiated at the suggestion of the Chief, Training Effectiveness Analysis (TEA) Division, U.S. Army Training and Doctrine Command (TRADOC), Systems Analysis Activity (TRASANA), White Sands Missile Range, New Mexico. The Center for Advanced Research of the Naval War College agreed to sponsor the research as being applicable to military training in general.

Many of the sources listed in the bibliography are of recent origin, authored by a select few innovative psychologists who are just now expanding the known limits of the role of human aptitude in learning and performance. This is a literature of specialists who do not always agree simply because they are employing imprecise research tools to study an incredibly complex subject. The reader should be aware that this paper does not represent the views of any one body of opinion. Rather extensive use has been made of the work of a few authors who have focused their research on developing a cohesive theory out of many conflicting, often confusing, studies. While the theory is not yet complete--much research is necessary to develop a useable body of principles and rules--a method for the conduct of research has been developed that can serve to point us in the right direction. Extensive use of this methodology has been made

in this paper in order to synthesize advances in individual differences in learning with the evolving Army training system.

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CHAPTER I

INTRODUCTION

The Problem

A military educational conference was held at College Park, Maryland, in April of 1979 to discuss the problem of declining literacy in the United States. Dr. James Flood, Assistant Professor in Boston University's department of reading and language, told the conference that 30% of high school seniors are not able to read their textbooks or news magazines. Eighteen percent of American adults lack basic literacy skills to the point where they cannot even fill out basic forms. Dr. Food emphasized that "certain" military personnel cannot even read field and technical manuals. This is not surprising. A 1975 U.S. Office of Education study found 42% of adult Americans to be poor readers or to be barely able to read well enough to cope with the problems of everyday living.

An example of how this decline in basic reading ability within the general population impacts on the Army is to be found in a recent study of reading abilities in the infantry conducted by the U.S. Army Infantry School (USAIS). The Infantry School became involved in the reading

problem when it was found that an inordinate number of enlisted men were failing the written portion of the infantry Skill Qualification Tests (SQT). One of the suggested causes of this failure was that infantrymen could not read well enough to comprehend written tests. Evaluation of the reading level of the SQT and supporting field manuals, indicated that the SQT were written at approximately the 10th grade level and the field manuals were written at about the 12th grade level.[1]

The Infantry School surveyed 189 junior officers and 1525 enlisted men selected so as to be representative of the infantry population, to measure reading levels. The survey used established reading tests to determine vocabulary, comprehension, and accuracy. Test results were correlated with rank, race, education, and scores on the Armed Forces Qualification Test (AFQT) (the AFQT measures an applicant's word knowledge, arithmetic reasoning, and spatial abilities). Results of this testing revealed that almost 100% of the officers read above the 12th grade level. However, a large percentage (56%) of the enlisted men in the grade E1 thru E3 read at the 5th grade or lower. A smaller percentage (about 15%) read at the 12th grade or higher, while the remainder of the enlisted sample, about 32% spread across seven enlisted ranks, read between grades 5 thru 1... Significantly, of approximately 1000 high school graduates between 300 and 400 read at between the 2nd and

4th grade levels.[2] Equally serious was the finding that good scores on the Armed Forces Qualification Test (AFQT) did not reliably predict reading ability. A large group (N=300) with relatively high AFQT scores read at less than the 5th grade level.[3]

In summary, the USAIS study tends to support Dr. Flood's gloomy picture of a school system that often fails to develop student literacy, and that certain soldiers cannot now read their training and maintenance literature. Virtually all infantry publications have been written for soldiers who could read at the high school level, while the majority of enlisted men in the infantry read at a level well below high school. This situation is particularly worrisome because, as will be seen, the Army's training system is heavily dependent on use of written texts by enlisted men.

Data from the Army's Recruiting Command indicates that during CY 1978, 86.9% of the applicants accepted for enlistment were placed in the lower two of four mental categories (CAT III and IV) on the basis of AFQT tests.*

In a recent survey at the Army's Armor School the distribution of 436 recruits across mental categories was:

CAT I - 3.1%

CAT II - 13.4%

---

* See Chapter II for a discussion of the Armed Services Vocational Aptitude Battery (ASVAB) and personnel selection criteria.

CAT III - 75.1%

CAT IV - 8.3% [4]

This high percentage of lower mental category people included 66% high school graduates. These findings are consistent with the infantry school study and appear to be representative of the educational quality of people joining the force. Keeping in mind that these mental categories are based largely on word knowledge and arithmetic abilities, the impact of the situation described by Dr. Flood on the military is clear. It is already difficult and costly to train soldiers on the complex equipment of today and so it may be even more difficult to train them on the increasingly complex equipment entering the inventory in the 1980s.

The problem of declining literacy has already impacted on the military in numerous ways. Millions are being spent to develop illustrated technical manuals to assist soldiers with reading deficiencies; remedial training is being given potential enlistees by the Department of Health, Education and Welfare's Office of Education to enable those who fail the AFQT to qualify for enlistment; and the Army's Basic Skills Education Programs are designed to upgrade the literacy and computational skills of Army personnel found deficient.

The magnitude of the problem is such, however, that the services may be unable to adequately man the equipment

needed to defeat the powerful and growing threat posed by the sophisticated forces of the Warsaw Pact.

Concerned about this large and probably growing gap between personnel performance capabilities and operational requirements, the Commander of the Training and Doctrine Command (TRADOC) obtained Chief of Staff of the Army approval in late 1977 to initiate a comprehensive study of Army training programs required to optimize the capabilities of major new weapon systems programmed for delivery to the force in the 1980s. The resultant Army Training Study (ARTS) report was presented in August 1978. While it is beyond the scope of this paper to review the data, conclusions, and recommendations of the ARTS report, it is appropriate to note that the study group concluded that training now being conducted in Army units was not achieving the established standard of individual and collective proficiency. In effect, soldiers were not trained sufficiently well to enable them to consistently operate their weapons and equipment to the level of capability for which they were designed. Further, evidence was found that inadequate training contributes substantially to morale, discipline, and retention problems.[5]

Given the declining quality of the available manpower pool it is clear that the Army's ability to take advantage

of developing technology is limited. These conditions suggest that advances in educational technology must be exploited apace with the hard sciences. To do otherwise is to risk the possibility that the Army will be denied the skilled manpower required for the battlefield of the future.

The Purpose

The purpose of this research is to determine strategies to apply educational technology in the development of instructional techniques and methods to capitalize on individual soldier aptitudes. The fundamental premise of this research is the notion that all of what may be best for PVT Jones may not be best for everyone else in PVT Jones' unit. What is needed are empirically derived training models, which will allow commanders to use the complex variables present when trainers, trainees, critical tasks, materials, and training objectives come together as an instructional event. While this research emphasizes the soldier component of the training problem, much of what is presented can and must be applied to the trainer as well.

Organization

This paper will investigate what is known about differences in individual learning against a background of the current Army training system and the Training Effectiveness

Analysis (TEA) Methodology being developed by the Army to improve training. The objective of this approach is to synthesize the proposed TEA methodology (and thus the Army training system) with the applicable research in order to develop a guide to future research. The paper addresses the following areas:

- An introduction to individual differences in learning within the context of modern psychological concepts of aptitudes, instructional treatments, and the interaction between aptitude and treatment. This interaction is referred to as an Aptitude-Treatment interaction (ATI).
- An appropriate military perspective as regards ATI.
- A review of the literature to include:
  - testing hypotheses and statistical analysis
  - effects of general abilities
  - effects of specialized abilities
  - effects of individual personality traits
  - instructional strategy development
- A research methodology that provides an initial framework for the identification of aptitude and treatment constructs.
- An implementing strategy.

Current Army Training System

The Solution. The reader should note that the Army has not been unaware of these trends and in fact has formulated concepts and programs to solve the problem. The existence of the TRADOC, which provides centralized control of the Army's school system and doctrinal development, under the command of a four star general, is evidence of the priority given training. TRADOC has been both aggressive and innovative in promoting change and in implementing modern educational developments. At the heart of the Army's solution to the problem is the school system which is organized by function/branch. Each branch school (Infantry, Armor, Ordnance, etc.) is responsible for developing branch-unique programs of instruction and the necessary field and technical manuals for its community. All TRADOC branch schools use the Interservice procedures for Instructional System Design Model (ISD), (TRADOC PAM 350-30) incorporating five phases (analysis, development, design, implementation, and control) in the development of training programs. They also use criterion referenced instruction (CRI) by which satisfactory job performance is identified and measured. Tasks, conditions, and standards are developed for each job as the basis for development of resident and non-resident programs of instruction. Training assistance to units in the field is provided by development of exportable training

packages for individual Military Occupational Specialties (MOS) and collective training tasks for units. This assistance takes the form of instructional texts and:

- Soldiers's Manuals (SM) which contain a listing of the critical tasks the soldier is expected to perform and the cues, conditions and standards for each task.

- Commander's Manuals (CM) which provide a listing of critical tasks for each MOS. This manual informs commanders what each soldier is responsible for knowing, who is responsible for training the soldier to criterion for each task and the references required.

- Skill Qualification Tests (SQT) which are designed to verify enlisted proficiency and eligibility for *promotion on a periodic* basis. Each SQT has three components; written tests, hands-on performance tests, and a certification component.

- Army Training and Evaluation Programs (ARTEP) are used to establish the tasks, conditions, and standards of performance for each company and battalion sized unit. ARTEP include common tasks such as chemical defense and first aid as well as branch unique missions.

- Combined arms tactical doctrine, i.e., combined infantry, armor, and artillery employment, is the responsibility of the Combined Arms Center (CAC) at Ft. Leavenworth, Kansas. CAC develops tactical doctrine for the

brigade, divisions, and corps, and operates the Command and General Staff College which trains officers from all branches.

- The TRADOC school system is supported by a scientific community consisting of combat development centers, operational test agencies and systems analysis organizations.

- Unit training is decentralized so that the battalion commander has the primary responsibility for the individual and collective training of his unit. The commander uses the SM, CM, ARTEP and unit-unique maintenance and mission training requirements to formulate quarterly training programs as the basis for his weekly training schedule. Standards are maintained by higher headquarters through use of SQT evaluations of each individual for each MOS and by periodic ARTEP exercises in the field, as well as by periodic maintenance , administration and weapon qualification evaluations of each unit.

Training Effectiveness Analysis

In support of this sytem, TRADOC has instituted a Training Effectiveness Analysis (TEA) program. This program is fundamental to sound combat and training developments as it serves to not only develop training programs apace with equipment and weapons, but it also provides data to enable the Army to determine if performance shortfalls are caused by training or equipment design error.

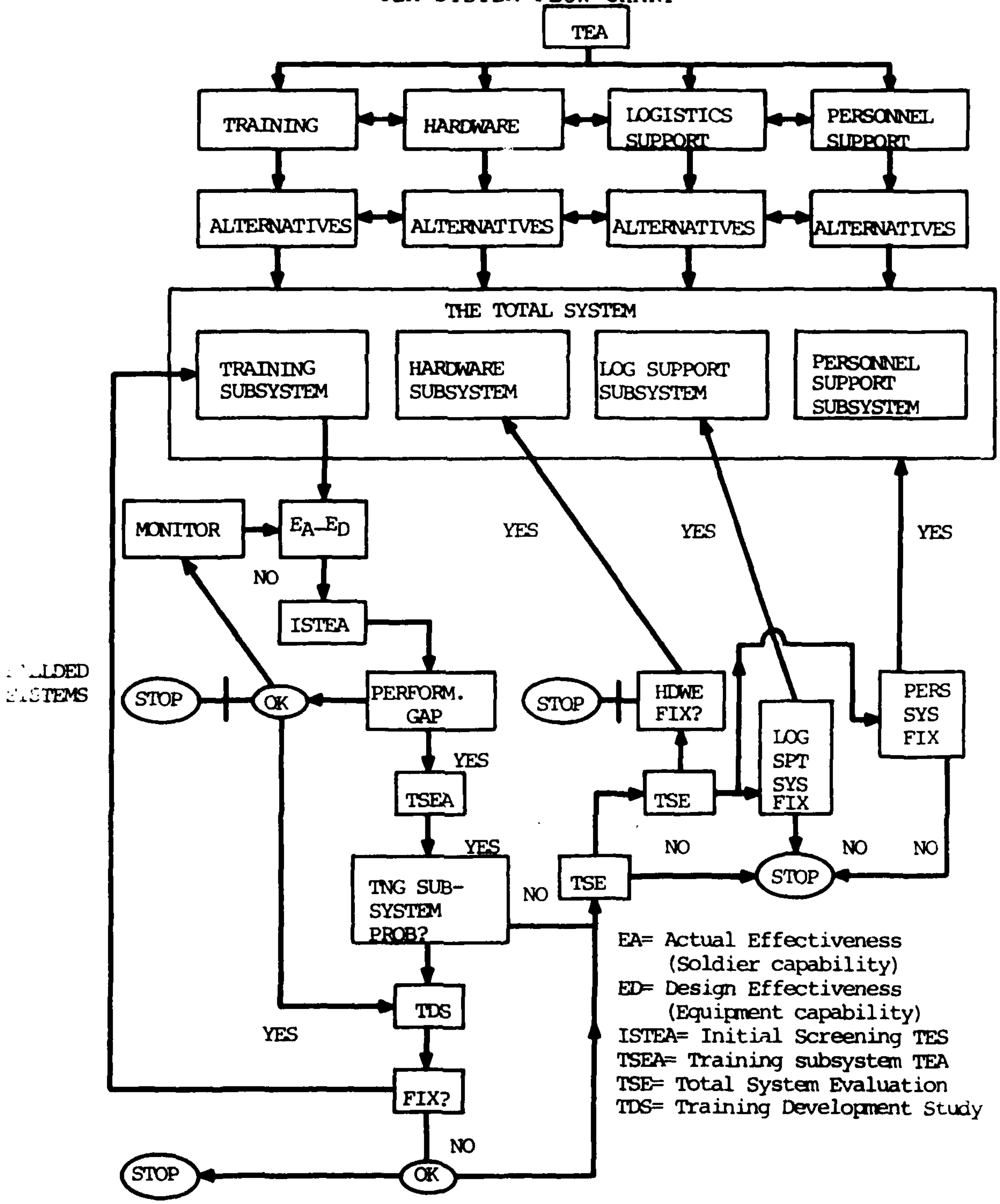
TEA are conducted during the equipment acquisition process to ensure that a training subsystem is developed with the same degree of scientific rigor as is the hardware subsystem. Central to this is an analysis of all feasible training subsystem alternatives to reduce training problems to a minimum. By definition, this entails testing to evaluate whether or not available manpower can be trained on equipment designs and if so, to determine the most cost effective way to do so. TEA are also conducted after a system had been fielded in order to verify the degree to which actual effectiveness matches design or to determine if a significant performance gap exists. Figure 1 depicts the role of TEA within the overall training and support system.[6]

TRADOC has established the objectives of the TEA system to be the use of interdisciplinary approaches in order to develop methods and techniques which: (not inclusive):

- best align equipment design (human engineering) and the training subsystem with the soldiers abilities.
- enhance the effectiveness of the training subsystem development process.
- establish equipment/weapons development and training development interface early in and throughout the acquisition cycle.
- increase assurance that ana'_sis, design, and development phases of ISD are accomplished in a timely manner prior to fielding the equipment.

FIGURE 1

TEA SYSTEM FLOW CHART



EA= Actual Effectiveness
(Soldier capability)
ED= Design Effectiveness
(Equipment capability)
ISTEA= Initial Screening TES
TSEA= Training subsystem TEA
TSE= Total System Evaluation
TDS= Training Development Study

- provide training related baseline data about generically similar fielded systems for inclusion in consideration of developing systems.

The TEA analyst is primarily interested in the determination as to whether a causal relationship exists between demonstrated soldier proficiency and attitudes and the training he has received. If a significant performance gap is found to be caused all, or in part, by the training subsystem, the TEA team must:

- examine the training subsystem in detail to relate the soldier, trainer, training environment, training subsystem and hardware subsystem factors/variables, to obtain precise definitions of training problem areas.

- identify, by excursion, related personnel and logistic support subsystems that cause gaps which may exist.

The Training Effectiveness Analysis (TEA) then looks at the training subsystem as complete packages put together by training developers using Phases I-III (analyze, design, develop) of the ISD model. These packages contain all media, materials, materiels, combinations and sequences needed by the trainer to implement phase IV of ISD, which is to conduct effective training.

The problem is that no one knows how to do all this consistently well. TRADOC has had no established TEA management system and past efforts have suffered from inconsistent methodology and quality. As a result, the Army has been unable to close the gap as performance of fielded

and emerging systems continues to fall short of design effectiveness in direct proportion to the decline in soldier quality and the rise in equipment/task complexity.

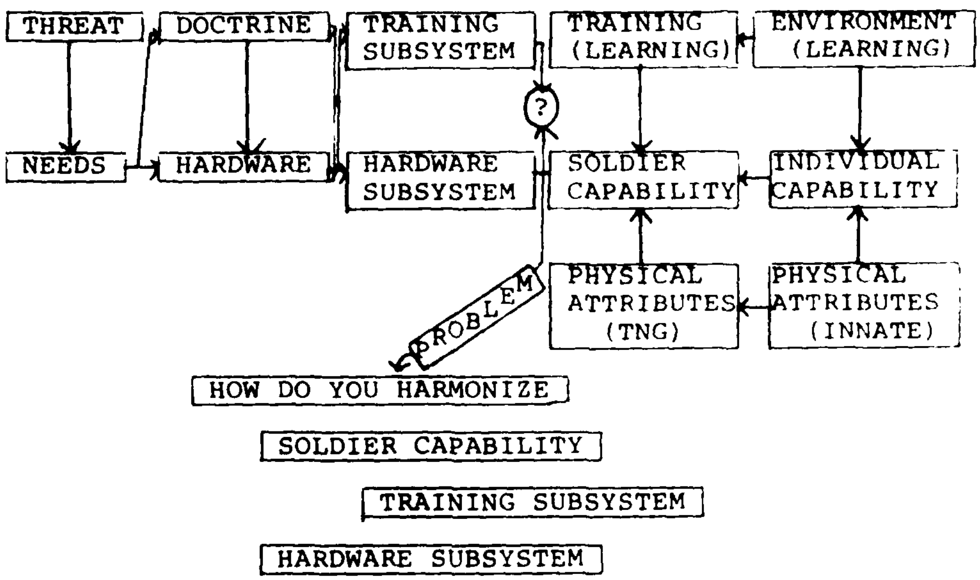
Basic TEA Considerations

In late 1978 Commander, TRADOC, designated the Director, TRADOC Systems Analysis Activity (TRASANA) at White Sands Missile Range in New Mexico as TRADOC Management Agent for the TEA as it applies to hardware systems. TRASANA has been authorized the necessary manpower spaces to develop the TEA methodology and to assist in the conduct of TEA done by other Army agencies such as the service schools. In addition, TRASANA is developing a TEA handbook, a management system and a priority system. In concept, the TEA methodology being developed by TRASANA provides for developing alternative training subsystems early in the developmental cycle so as to compare the effectiveness of each alternative in terms of demonstrated soldier performance and cost. The best alternative(s) is/are selected for implementation. Basic TEA considerations are outlined in Figure 2.

The TEA process being developed to harmonize these basic considerations includes research to develop a "soldier profile" through identification of individual learning styles, best expressed in terms of psychological processes as to how the individual soldier learns best. In other words, TRASANA is seeking a conceptual construct to describe how trainees

FIGURE 2

BASIC TEA CONSIDERATIONS



are alike and how they differ from one another. Once this has been established the TEA process seeks to develop an understanding of the instructional methods and techniques best suited to individual learning styles to facilitate learning and skill retention. The final phase is to determine if the available soldier capabilities match the demands of the equipment. If they do, then the researchers must develop the personnel selection criteria and assist the appropriate branch school to design (Phase II, ISD) and develop (Phase III, ISD) the training subsystem. If soldier

capabilities do not match the demands of the equipment then the hardware should be redesigned until the selection criteria and training subsystems provide the appropriate quality crews who can operate the equipment to design capabilities.

CHAPTER II

AN INTRODUCTION TO APTITUDE-TREATMENT INTERACTION (ATI)

General Perspective

For years it has been believed by educators and instructors alike that psychologists have been making substantial progress towards developing rules, laws, principles, and techniques of learning that would, if understood by all, guarantee student performance. Recently, however, both psychologists and educators have begun to have doubts. McKeachie[1] believes that Thorndike's principles of learning appear to be "crumbling ": that at least for significant numbers of people, defining objectives may not result in better learning; that learning by small steps may be less effective than by big steps; that delayed knowledge of learning/training results may actually be a better measure of the effects of instruction than immediate knowledge;and that rewards may not motivate all students to do better. Cronbach and Snow go even further and state categorically that "there is no such thing as a homogenous group of students or a specifiable method of instruction."[2] In other words, for many soldiers the standard course of instruction is not the best course of instruction. If this is true, and the literature provides impressive evidence that it is, it suggests the need to capitalize on individual differences

to narrow the growing gap between soldier capabilities and equipment-job requirements. While some may hold that simply by training soldiers to criterion we can erase the effects of individual differences (ID's), a strong case is emerging that we cannot in fact erase them so much as mask them. In masking the effects of ID's it is likely that the Army is merely deferring payment, payment ultimately to be made in the form of increased time to train, accelerated decay of individual skills and, ultimately, degradation of unit readiness. "What lies before us is the task of accumulating knowledge about how a person's characteristics influence his or her response to the alternatives educators can offer or invent."[3]

The Concept of Interaction Research

One approach to the analysis of instructional processes as they relate to individuals is founded on the investigation of learner characteristics and educational treatments. The initial task for researchers is to develop a conceptual framework to describe individual learner traits. Cronbach and Snow (1977) do so in terms of aptitudes. They define an aptitude as "any characteristic of a person that forecasts his or her probability of success under a given treatment."[4] Obviously, in addition to our present assessments of mental ability and aptitude areas, this definition may include prior achievements, sex, physical condition, interests, ethnic background, information-processing

capabilities and styles and a host of other, non-test variables. Many of the implications of this aptitude definition remain to be developed, but, as will be shown, some initial directions have been formulated and proven useful. Treatment is defined as "any manipulable variable."[5] A treatment variable consists of one or more tasks plus the manner of delivering the instruction, such as curriculum structure, directions, feedback, step size, program versus lecture instruction, etc. Unfortunately, at present there is no firm consensus as to the utility of major constructs of instructional treatments as they relate to target population learning styles. However, the literature is rich in the formulation of testable treatments, many of which will be discussed in following chapters in a context relating their appropriateness for use with different aptitudes.

Learning outcomes are best viewed as "interactions." "Interaction research concerns itself not with interactions of aptitudes and treatments in isolation, but as they relate to learning outcomes. Lewin's interaction formula...states this relationship: $B=f(P,E)$, or behavior is a function of person and environment."[6] If we view the problem of interaction as an equation, as Lewin has done, then we must ask not only what skills should be learned and in what manner can they best be taught but we must also ask in what different ways are evidences of learning behavior to be measured? Do we demand demonstrated mastery, familiarity, or merely the

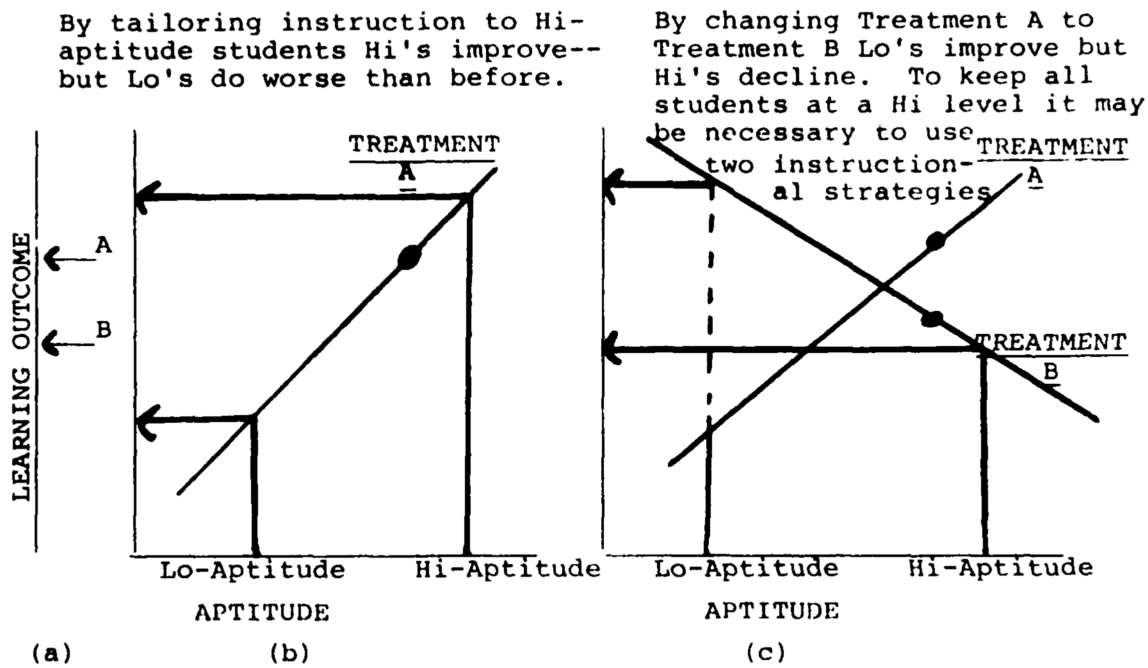
ability to transfer the knowledge to different situations?

Three aspects about the relationship of individual differences (ID's) in learning from instruction seem clear: (1) ID's are far more complex than can be accounted for in a rank order conception of intelligence and they are more fundamental to human learning than most curriculum's recognize, and (2) ID's not only predict individual differences in learning outcome;they also interact with alternative instructional strategies, and finally (3) ID's can be used by the instructional developer, thru the medium of interaction research, to improve instruction for almost everyone. To illustrate the interaction between an aptitude and an instructional treatment refer to Figure 3 and the explanatory paragraph.[7]

Figure 3 (a) simply portrays the differences in outcome of two alternative instructional treatments. Treatment A is considered better than B because average student gain scores are higher after A than after B. Individual student differences of learning styles were not considered here--rather teaching strategies were the central concern, and learning outcomes were measured by post te [illegible] or averages. The addition of learner aptitudes changes Figure (a) to Figure (b) by adding an abscissa representing student aptitudes. A regression line, for the tasks being taught, is determined by measuring individual aptitudes

FIGURE 3

Hypothetical results of: (a) traditional instructional comparisons; (b) studies including an aptitude variable; and (c) studies testing for aptitude-treatment interaction.



before instruction and then plotting each student as a point on the graph by connecting the aptitude score to the post instruction achievement score. The resulting regression slope can be viewed as a sort of running average across varying aptitude levels. Naturally, when results look like this, instructional developers attempt to change the instruction to benefit the low achievers, while hoping that the high achievers will continue to perform at a high level despite changes in the instructional media or methods. However an

impressive body of research now suggests that Figure (c) is the more likely result. By improving instruction for students with one type of aptitude (or lack of aptitude) instructional effectiveness is likely to be reduced for others. In this type of situation the proper course of action may be to assign higher aptitude students to treatment A and lower aptitude students to treatment B. Results of this sort indicate the presence of an aptitude-treatment interaction and it is exactly this capability the Army seeks to attain through use of ATI research in the TEA process. Hopefully, instructional theories can be built on such co-relations if research results lead to full understanding of aptitude-treatment interactions.[8]

Result (c) in Figure 3 is an example of a "disordinal interaction," one in which the regression slopes cross. Traditionally, disordinal interactions have been interpreted as being "significant," in that this definitely shows a specific treatment to be best for specific aptitudes, while ordinal interactions, a situation wherein treatment regression slopes do not cross, have been dismissed as not "significant" or as indicating that no interaction is present. Modern researchers however, do take ordinal interactions seriously because experience has shown that the aptitude x treatment interaction regression slopes need not be so pronounced as to cross to contain useful information for instructional

developers seeking to improve individual terminal performance by manipulating the manner in which the instruction is presented.

Present State of the Art

Over the past 20 years research into aptitude-treatment interactions has grown substantially. This growth has been characterized by interest in analysis of human information processing in perceptual, cognitive, learning and problem solving tasks. Of major interest in this work is the analysis of the complex learning that is relevant to the real world. While there are literally thousands of individual differences which can never be included in theory, psychologists have recently managed to impose a cohesive structure on a confusing and often contradictory field of research. In particular, Cronbach and Snow have contributed immeasureably to the sum of our knowledge with their recently completed (1977) Aptitudes and Instructional Methods.[9] Some 12 years in preparation, this "handbook" for researchers defines relevant concepts in a mosaic which portrays the central concerns and contributions that have been made in the discipline. It instructs the novice and guides the seasoned researcher to avoid the pitfals of the past. In so doing Cronbach and Snow have prepared a road map by which the researcher can produce data that are of practical use to the instructional developer. This road map is oriented on the principle that learning is the result of neither individual

aptitudes nor specific instruction but rather the result of the interaction of the two to produce learning.

If one accepts this view of learning it is evident that researchers must seek a combination or interdependence of aptitudes and instruction to better develop optimal balances of the best educational program for the individual learner. The Army's long range need is for understanding of the causative factors that lead a soldier to learn more and to retain it longer as a result of one instructional experience rather than another.

The reader is well advised at this point to realize that to "categorize substantive findings on Aptitude-Treatment Interactions presents an insuperable problem. Dozens of abilities and dozens of personality traits are used as aptitude variables (along with sex, age and social class). Treatments are likewise heterogeneous, and there is no conventional basis for classifying them."[10] Thus, no magic formula will be presented. Rather the contribution of this paper will be to focus future research efforts to improve soldier training within a framework of the existing organization, methodology and the Army training and classification systems, so that we may find out what has happened in a training experience and what has not happened. This knowledge will hopefully allow us to capitalize on individual differences by developing an individual soldier profile relative to learning performance; by refining our personnel

selection criteria; by more precisely defining critical tasks; and by modifying our instructional alternatives to enhance performance and skill retention.

CHAPTER III

A MILITARY PERSPECTIVE

Having discussed the present and growing personnel performance gap, the Army training system, the need for and c cept of TEA, and defined Aptitude-Treatment Interaction research, it is necessary to briefly look at past and present attempts by the military to address the problem and by so doing to more precisely focus on Army needs

Current Personnel Classification Procedures

Armed Services Vocational Aptitude Battery (ASVAB) and Career Management Field (CMC) Personnel Selection Criteria. The basic objectives of the ASVAB are: (1) Established mental qualifications for enlistment for use by all services; (2) Selection of enlistment applicants for a particular military occupation or training course; (3) Classification and assignment; and (4) To test high school seniors. ASVAB Forms 6 and 7 are parallel forms of ASVAB 5, administered at the Armed forces examining station, along with a short interest inventory (The Army Classification Inventory).

Information about aptitudes is then provided by the ASVAB; Army requirements are established in quotas set for each military occupational specialty (MOS) which are grouped

by Career Management Fields (CMF). There are nine broad CMF used by the Army. These are: Combat (CO), Field Artillery (FA), Electronics (EL), Surveillance and Communications (SC), Operators and Food Handlers (OF), Mechanical Maintenance (MM), General Maintenance (GM), Clerical (CL) and Technical Skills (ST).

Research on matching aptitudes to military training has shown that various combinations of aptitudes and abilities are of value in predicting success in given career fields. In the classification process, the aptitudes of individuals are matched to the demands of the MOS. The current battery consists of a series of subtests that are combined into 6 aptitude area composite scores for high school students and 9 aptitude area composites for the active Army. These aptitude area scores are a primary basis for assignment. Each entry level training course has a prerequisite score in the appropriate aptitude area.

Aptitude area composites, subtests, and their correlation with the CMF are portrayed in Table 1 on the following page. A summary discussion of subtest and aptitude area composite composition is at Appendix I.

TABLE 1

APTITUDE AREA COMPOSITES

TEST	APTITUDE AREA COMPOSITES									
	GT	ST	CO	FA	EL	OF	SC	MM	GM	CL
GENERAL INFORMATION (GI)			GI	GI		GI				
NUMERICAL OPERATIONAL (NO)										
ATTENTION TO DETAIL (AD)			AD							AD
WORD KNOWLEDGE (WK)	WK						WK			WK
SPACE PERCEPTION (SP)			SP				SP			
MATHEMATICAL KNOWLEDGE (MK)		MK		MK				MK		
ELECTRONIC INFORMATION (EI)				EI	EI			EI		
MECHANICAL COMPREHENSION (MC)					MC		MC		MC	
GENERAL SCIENCE (GS)		GS							GS	
SHIP INFORMATION (SI)					SI			SI		
AUTOMATIVE INFORMATION (AI)						AI		AI	AI	
ARITHMETIC REASONING (AR)	AR	AR	AR	AR	AR		AR		AR	AR

SYMBOLS: APTITUDE AREA COMPOSITES

FA = Field Artillery
EL = Electronics Repair
OF = Operators and Food
SC = Surveillance and Communications
CO = Combat
MM = Mechanical Maintenance
GM = General Maintenance
CL = Clerical
ST = Skilled Technical

Table 2 portrays the correlation between mental category (a function of individual achievement on the AFQT) and the GT score, i.e., mental score with spatial perception factors removed.

TABLE 2

MENTAL CATEGORY AND GT SCORE CORRELATION

MENTAL CATEGORY	GT SCORE
I	130-160
II	110-129
IIIa	100-109 (Avg Percentile)
IIIb	90-99
IVa	80-89
IVb	65-79
V	50-64

Discussion

While the ASVAB has demonstrated a good reliability coefficient (range for the composites is between .88 and .92) the validity coefficients have not been established.[1] Correlation of the subtests against MOS specific critical tasks is being undertaken by the Army Research Institute; (ARI) but, to date, the tests have been validated against only supervisor/survey opinion. While the ASVAB depends

heavily on cognitive factors for aptitude classification, the Army has turned increasingly to hands-on performance training that places few cognitive demands on the entry level soldier. There are however, many cognitive demands remaining for high skill level training tasks. This said use of the ASVAB is a defacto recognition that people differ not only in size and shape but in their aptitude for specific types of jobs. More importantly, by the existence of the ASVAB the military acknowledges that an aptitude for learning a skill can be measured and applied in an operational selection situation. People who are high on the measure are likely to be successful in jobs involving that skill, while people low on the measure are likely to perform inadequately. Because this is true, it is reasonable and logical to hypothesize that people can also be high in aptitude on specific instructional treatments and will be more successful learners in instructional situations involving that aptitude. Unfortunately, the ASVAB does not make this connection. Yet it is true that the services have made numerous attempts to predict success in training, and in the military overall, based on individual differences. They have also attempted to tailor instruction to individuals so as to remedy learning deficiencies uncovered by the ASVAB and individual performance evaluations. Several of these studies appear to have been well done and are worth reviewing.

Profile of a Successful Marine[2]

In this study men who joined the Corps during the first year of the all-volunteer force were followed through two years of service. Background and test selection data were related to early discharge to produce a profile of a successful Marine. When reviewing these data the reader is cautioned that not only do people vary between one another but they also vary within themselves from day to day. A person may not behave tomorrow as he did today. This tends to make predictions based on profiles actuarial rather than absolute. With this in mind, let us turn to the profiles of success and failure developed in this study.

The analysis considered only age, race, educational level, number of dependents and aptitude and attitudinal test scores. Three separate profiles were developed:[3]

- Profile 1. based on:
  - -- educational level. age and an attrition composite developed from the ASVAB scores and an attitudinal survey.
  - -- 14 months of service
  - -- N = 3.000
- Profile 2, based on:
  - -- educational level (HSG vs. NHSG), age and mental group.
  - -- 14 months of service
  - -- N = 3,000

- Profile 3, based on:

  -- educational level as a function of number of grades completed, age, mental group

  -- 24 months of service

  -- N = approximately 46,000

Results

- Most discharges occur in the early months of training. Unsuitable troops are identified easily and quickly.[4]

- Profile 1 is the best predictor of early attrition. Non-high school graduates (NHSG) and low ASVAB scores, particularly low AFQT/GT scores, are important predictors of attrition. However, the "attrition composite" in profile 1 is based heavily on a non-standard attitudinal test whose transparent nature is such that it cannot be recommended for implementation. Profile 1 does however, serve to illustrate the value of such an approach if a non-transparent attitudinal test were available for inclusion in the ASVAB.[5]

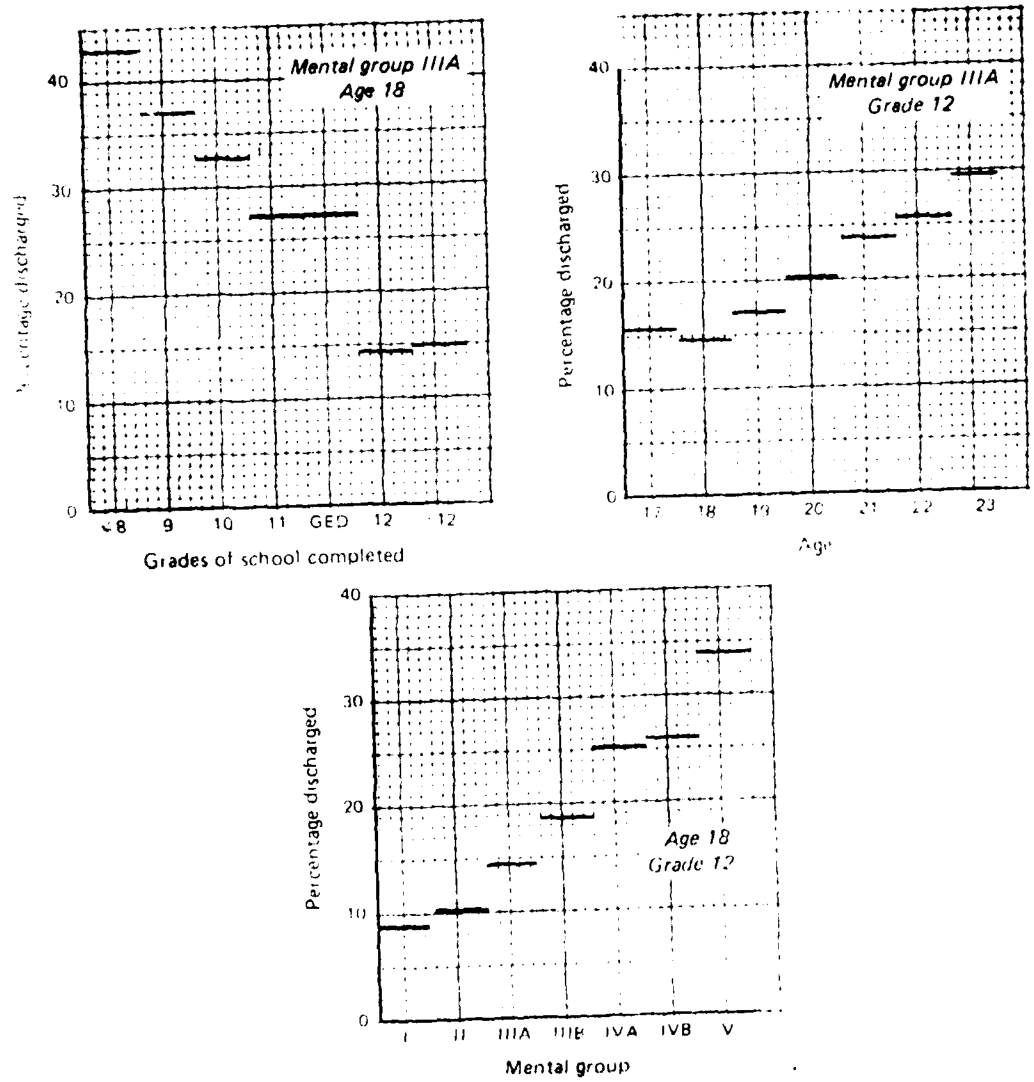
- Profile 2 and 3 were successful at predicting attrition with Profile 3 being the more useful as it better predicts success for non-high school graduates.[6]

- The most successful Marines are most often those who have completed high school, enlisted at an early age and scored high on the ASVAB mental group composites.[7] (CAT I through IIIa.)

• Race and number of dependents were not found to be significant. Once educational level, mental category and age are known both minority and majority racial groups were shown to have identical chances of success. Figure 4 portrays the premature discharge rates as a function of education, age, and mental group.[9]

FIGURE 4

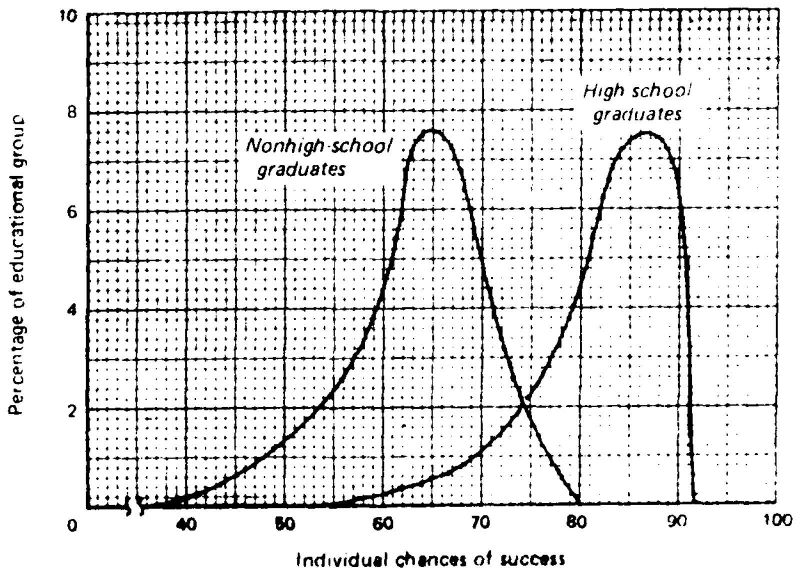
ILLUSTRATIONS OF DISCHARGE RATE AS A FUNCTION OF EDUCATION, AGE, AND MENTAL GROUP



•   The distribution in chances of success by educational group (HSG vs. NHSG) is shown in Figure 5.[10]

FIGURE 5

DISTRIBUTION IN CHANCES OF SUCCESS BY EDUCATIONAL GROUP FOR PROFILE 3



This profile of success is consistent with a previous analysis of USMC school assignment and performance also performed by the Center for Naval Analyses. This study (N = 24,380 students in 84 courses) determined, among other things, that students in electronics courses (EC), who

were ineligible by virtue of low AFQT and/or ASVAB aptitude composite scores but were sent to the school in spite of ineligibility,failed almost four times more frequently than eligible students.[11] Further, the failure rates of the ineligible non-high school graduates were more than three times the failure rates of the eligible high school graduates. Thus, if the educational and aptitude requirements for these courses had been met, fewer students would have been needed to produce the same number of graduates. Once again, measures of general intelligence and educational levels were found to be excellent predictors of successful learning behavior.[12]

The impact of educationally unqualified soldiers extends beyond the school system into operational units. The Army's operational testing of the complex AN/GSG-10(V) Tactical Fire Direction System, TACFIRE, was severely hampered by the non-availability of qualified soldiers. The test agency concluded:[13]

> The complexity of TACFIRE will place a significantly greater unit and formal training burden on the artillery than presently exists... one third of the available manpower pool of fire direction enlisted personnel do not have the aptitudes which will allow them to pass the TACFIRE training courses...training deficiencies are a significant factor in the TACFIRE failure rate.

Discussion

The reader is now asked to recall the background synopsis introducing this paper, wherein it was noted that a large percentage of entry level soldiers were not high school graduates, most of whom scored in the lower percentile of the AFQT as did a large percentage of the high school graduates.

The results of the above two studies would indicate that a large percentage of these soldiers will fail to successfully complete either their training or their enlistment or both. One must ask two additional questions: (1) How many of these men would have been successful if they had acquired additional skills through individualized training that compensated for their lack of education and reading/ arithmetic deficiencies? and (2) How much better would the successful students have performed if they had not been burdened with training structured for the norm, which was probably tailored to accommodate low skill people who comprise the majority of entry level personnel? Obviously, it will require further research to answer these questions, but the lack of an answer does serve to emphasize the importance of TEA and the need to proceed with ATI research. This said, a research experiment that attempted to develop the potential of low ability personnel has been completed with some success. While this experiment did not in fact deal consciously with ATI, it does provide an insight into

the problems of individualizing instruction for low achievers. As such it is an appropriate lead-in to an in-depth discussion of ATI research.[14]

Developing the Potential of Low Ability Personnel

This project was a one year effort by the Human Resources Research Organization (HUMRRO) to develop the learning capacity of marginal Army personnel.[15] The approach to this effort was to design an "individualized" instructional program based on each man's entry level capabilities and interests.[16] The goals were to provide participants with the skills and knowledge to manage their own training and future development, while simultaneously acquiring basic reading and arithmetic skills. Participants(N = 24) were all mental category IV personnel who had completed AIT successfully. Twelve of the 24 were high school graduates; their mean reading level was at a grade equivalent of 6.86. The mean full scale IQ, measured on the Weschler Adult Intelligence Scale (WAIS), was 91. Thus they were a distinctly below average group.[17]

The HUMRRO staff constructed an operational teaching strategy that provided for the following:[18]

- Feedback
- Individualized instruction to include self-selected goals.
- Private and small (5 to 6) group work spaces.

- A "protective" interface between training and larger organization needs.

- Staff selection emphasizing training in interpersonal relations and flexibility and the ability to accept criticism.

The strategy was based on the hypothesis that, although conventional wisdom held that marginal students are of fixed and limited capacity, the creation of a favorable environment for learning would result in noticeable gains in measured intelligence and in basic skills. "...the staff made the unstated assumption...that each participant, given opportunity, would orient himself and organize his efforts towards achieving some goal."[19] The event was dramatically different. The lack of structure led to "chaos and a series of disciplinary problems...."[20] This is largely consistent with the literature on ATI research. Low ability people commonly differ from high ability people in their lack of organization to achieve goals. In this case the researchers found that training requirements were...often secondary to distractors; "spending money to buy clothes, stereos and cars, drinking, smoking marijuana and peer confirmation for their masculinity were often the main focuses of their attention."[21] The first lesson learned then was that a lack of structure impedes learning by creating chaos and disciplinary problems. Low ability personnel need to:[22]

- Improve their basic skills
- Learn to respond positively to authority figures
- Experience success
- Learn to use the community to develop personal resources.

Trainers of low ability personnel need to understand that:

- The training environment is as important as the curriculum.[23]
- Instructor must focus on how their behavior contributes to the disciplinary problem.[24]
- Each trainer must be capable of providing basic skills,tutoring and evaluation to help design independent study programs and counseling.[25]

Results

After a period of from six to ten months this experiment demonstrated that intense, individualized instruction of low ability personnel (grouped on the basis of their lack of basic skills and low IQ scores) could improve their performance (the IQ mean rose to 96.48) and more importantly, could develop abilities to formulate their own goals and means of achieving them.[26] While the participants had a history of few sustained, goal directed, self-development activities, after training the average participant was involved with eight self-development activities. Their

abilities to interact with authority figures had also improved.[27] In other words there are strong indications that CAT IV soldiers are not functioning at their full capacity prior to entering the service and that they will present disciplinary problems for their units until they are trained. On the other hand, these CAT IV soldiers were still functioning at below the GT score 50th percentile even after six months and more of intense individualized instruction.

At this point the reader must seriously question the Army's capability to devote this amount of resources to achieve so small a gain. Further, an emphasis on individual well being and achievement of civilian related job skills (no matter how satisfying), rather than on individual and unit training, may be counter productive to the development of a cohesive and responsive Army. The authors of the HUMRRO study, however, believe that individualized instruction, to improve basic skills, to instill discipline by improving interactions with authority figures, and to provide an experience of success through development of personal resources, is well worth the cost. Given the numbers of low ability personnel entering the Army and the growing performance gap, they contend that it is worthwhile in "terms of greater technical skill acquisition and a greater sense of responsibility and accountability."[28]

Whether or not this program with this type soldier is cost effective, if one assumes that prior civilian educational experiences resulted in low learning levels, the experiment did demonstrate an interaction of aptitude (low) with an instructional treatment. This treatment was characterized by quality control of instruction/learning, based on performance criteria, small group and peer instruction, feedback within a functional context wherein students had to use previous learning to achieve new learning within a framework of self-generated goals and organization and discipline.

As will be seen in the next chapter, this is consistent with the literature on ATI and tends to support a conclusion that individualized instruction based on aptitudes and traits is a workable concept. It also demonstrates that the broad diversity of ability "makes collective descriptions of limited value...many (students) spent most of their time resolving emotional problems which made concentration on other skill development nearly impossible."[29] In other words if the Army is going to train them at all it will have to be individually--at least until basic skills, discipline and self-development skills are acquired.
All of this leads to the next step into the world of ATI, a review of the literature to encapsulate what is known about ATI and what should be learned before making changes to existing training programs and procedures.

CHAPTER IV

A SUMMARY OF THE LITERATURE

A review of the literature of ATI reveals a dismaying diversity of theory, experimental design and contradictory, non-replicable results. It is important to note straight away that "no interactions are so well confirmed that they can be used as guides to instruction."[1] No general principles have been developed and no generally agreed language to describe aptitudes, treatments, nor type interactions has emerged to guide the researcher or instructional developer in his endeavors. The literature is as rich in criticism of past studies as it is in conclusions. General principles have not emerged because study findings have rarely, if ever, been confirmed when different tasks or curricula were used or when similar studies on the same tasks with different learners, or the same learners at different times, were undertaken.

As Bond and Glaser have noted in their review of Cronbach and Snow (1977):[2]

> Even when allowance is made for the methodological flaws of many studies, one is still struck by the lack of a coherent picture and the absence of any prescriptive assistance to instruction.

However, this same review noted a trend that cannot help but cheer those engaged in this research.

> A pattern seemed to emerge suggesting that the more promising results appeared in precisely those situations when investigators were forced, in a word, to think quite explicitly about what they were doing because no ready-made and labeled aptitude tests were available.[3]

Precisely so. What is available are lessons learned that can be used to analyze specific instructional situations. As quickly becomes evident, the use of existing psychometric measures in ATI research must be reinforced by scientific analysis of the processes "that relate aptitude, treatment, and the knowledge or skills being learned."[4] Because neither the traditional psychometric tests nor past ATI studies provide adequate prescriptive data, they do not establish a basis adequate for design of instructional treatments that correlate with individual aptitudes. However, recent research has identified the methodological errors of past studies and formulated methods for future research on aptitude-treatment interactions and statistical analysis techniques.[5] The Defense Advanced Research Projects Agency (DARPA) has also compiled an extensive, selective review of the literature on instructional strategies and individual differences.[6] The reader interested in tracing data to primary sources or desiring an overview of the central contributions being made in this field can simply turn to these volumes to gain admission to the discipline.

The purpose of this chapter is to encapsulate the scope and range of the research in order to focus what is known and what is known to be unknown within a context of the TRASANA TEA program. What follows is a summary of the major lessons learned in ATI research to date. In short, this and following chapters set forth how what we know about ATI can be used in TEA and what remains to be explored.

Lessons Learned About ATI

Aptitude-Treatment Interactions exist. "The substantive problem...is to learn which characteristics of the person interact dependably with which features of instructional methods."[7] Careful analysis and synthesis of the literature reveal quite a bit about what is known as well as what remains to be discovered about ATI.

Aptitudes

- While controversy exists over whether researchers should concentrate on a few key dimensions of aptitude or try to consider the many dimensions required to fully characterize the individual, it appears best to focus initially at least, on a short list of significant traits.

- Measures of general abilities such as those measured by the ASVAB AFQT/GT subtests, (word knowledge, (WK); arithmetic reasoning, AR); etc.) predict the amount learned or the rate of learning or both. Special abilities such as psychomotor skills, auditory abilities, biologic

reactions, etc. interact less frequently with instructional events and do not relate to subsequent performance as strongly as do general abilities.[8]

- Measures of scholastic ability or academic achievement do often predict learning of new material--the correlation is often in the range of 0.40 to 0.60.[9] However, individuals learn at different rates and also adapt to different instructional conditions at different rates. Insofar as learning rates are evidenced by performance, the effect probably cannot be attributed to any single aptitude but has to be attributed to information processing skills and motivation.*

- "intellectual development is cumulative: the person who succeeds in early intellectual adaptations lays down skills and attitudes that help him...later.... For this reason measures of past achievement are thought to be good indicators of learning aptitude."[10]

Interaction

- Significant interactions are more likely to be realized in treatments extending over several weeks than in short experiments.[11] Training courses selected for

* Information processing and associated research models will be described later in Chapter V, Research Methodologies. Suffice it to note here, that this is a complex area of aptitude differences dealing with the learner's ability to detect, analyze and evaluate incoming information. Motivation, thought by many to be a key factor in learning, will be discussed separately later in this chapter.

evaluation of learning style interactions should be of at least two weeks duration.

- One can mask individual differences only by restricting the faster learner. Students high in an aptitude central to the training at hand or high in general ability will profit from the opportunity to process the information at their own pace in their own way. Lows however tend to be handicapped by this type instruction. This is not a universal rule, but it encompasses a wide range of results.[12]

- For some instructional content, using audio-visual/symbolic techniques to replace or supplement verbal instruction helps persons of low general ability to learn.[13] This has not proven to be as beneficial to high ability people and may even be detrimental to them by lowering their motivation.

- No evidence has been found to support a thesis that programmed instruction, using small steps with continual overt response and correction techniques, is helpful to lows. Nor has branching to enrich programmed instruction been found to be helpful to highs. The conclusion is not that such treatments do not interact with student aptitudes; it is that the interactions are not predictable. Sometimes they (the programmed texts) do help as predicted. Sometimes not, and sometimes they interact in the direction opposite to that predicted.[14]

- Instruction that is heavily verbal frequently is more fruitful for those of high general abilities, but is detrimental for lows.[15]

Prior Learning

- Findings that most clearly match special aptitudes to special instructional techniques are the interactions that use prior experience. A treatment works most efficiently for those who have already developed skills in using the treatment. Thus, inferior performance need not be a fixed inaptitude as the ability to perform evidently is rooted in experience with a specific type of instruction. Rather, the poor performer is simply not yet ready for the instruction.[16] This was clearly and consistently demonstrated during ARTS sponsored TEA in 1978.*

Personality Factors

Interactions traceable to personality factors have been found in the ATI literature with "considerable frequency, and some combinations of variables and treatments appear more promising than others."[17] Personality variables are many, complex and evidently not always completely understood by ATI researchers.

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* See the Army training study, Final Report, data book, Aug. 1978, pages SQ 2-3 which discusses the influence of prior experience on training time and costs to attain criterion terminal performance.

However, one of the basic principles of psychology is that all behavior has a purpose. In the simplest terms, a person is motivated to act or to refrain from acting in order to satisfy a perceived need (aside from the need to satisfy basic physiological needs) such as to reduce anxiety or to satisfy a need for achievement. Thus personality variables may be viewed for purposes of ATI research as motivational constructs. A major problem for the Army, however, is the fact that the Department of Defense (DoD) does not now routinely administer personality inventories. As noted by the Office of Naval Research study on the profile of success in the Marine Corps, there is need for the "development of non-transparent psychological tests designed specifically to predict success in military service."[18] Such development is indeed required. At this time a great many personality variables are surfaced in the literature, often without a common, cohesive behavioral definition of the trait. This said, it is evident that some personality variables do seem to hold promise for ATI research. These are: traits of anxiety, and need for achievement, or their opposite extremes, low anxiety, low need for achievement. Anxiety, sociability, and need for affiliation may also have strong effects on motivation.

Before going on it is important to differentiate between a personality trait and a state. One who is generally

fearful, nervous, and concerned to the point of distraction from the task at hand, could be labeled as an anxious person--this being his predominant condition. Anxious learners under even mild stress may become paralyzed by confusion and turn in an inappropriate performance or even give up entirely. Conversely, one who is normally calm, sedate, and secure could be moved to a state of anxiety by circumstances. This anxiety state is similar to an anxiety trait but is temporary and need not necessarily be treated by individualized instruction. Some studies do indicate that a mild degree of anxiety is necessary to motivate a student to learn.

- Single personality trait studies have identified the important variables discussed above but no single trait has been found that, by itself, contributes as significantly to the students response to instruction, as they do in combination. As an example, a study by Domino produced consistent evidence of interactions of instruction with learner need for achievement. Performance was better when the instructor encouraged the student's natural style. Domino's aptitude variable was the difference between achievement through independent action (Ach i) and achievement through conformity (Ach c) to rules and the desires of others. Domino administered the California Personality Inventory (CPI) and scored only the Ach i and Ach c scales. Those high on independence describe themselves as self-reliant,

demanding, and mature. Those high on conformity describe themselves as responsible, sincere, organized, and efficient. These are both favorable self images that differ in kind. Those whose self-image is not favorable will not score high on either scale. High independents did best when the instructional media favored conformity.[20] Further, there is evidence that anxiety traits combine with the need for achievement, with students high on anxiety being helped more from a teacher-dominated class structure and students low on anxiety doing better with student-centered instruction. From these experiments a considerable theory has emerged emphasizing the combination of need for achievement with anxiety as the predictor.[21]

- Motivation which, of course, often results from recent motivational experiences such as expectation of reward and understanding of relevance, can also be conditioned by long term success or failure in like circumstances. Many research scientists aggreate measures of anxiety, sociability, need for power and/or achievement within concepts of motivation. Cronbach and Snow employ the concept of "defense motivation" and "constructive motivation" to categorize individual motivation traits. Defensive motivation refers to those who are alert to threats and who organize their responses to the environment so as to handle a particular threat effectively. Constructive motivation

encompasses need for achievement or other needs that tend to motivate towards seeking success.[22] Motivation appears to occur in a three phase cycle:[23]

1. The motivated state
2. A stress situation leading to action
3. Relief as a result of action.

An impressive amount of evidence confirms the importance of constructive motivation to learning. The Domino study indicated that motivated students respond better to instruction that places responsibility for learning onto the student. It is not equally clear that the unmotivated student responds less well to less directive treatment, but the literature does indicate that students who are not motivated to learn need more direction.[24]

Motivation as it relates to recent experiences may be such a transient trait that it is difficult to envision a way for it to be of much use to the ATI researcher except in terms of motivated or not motivated. One approach would logically seem to be to determine what motivated the soldier to enlist and to separate his expectations regarding training and education and seek to capitalize on these to maintain his motivated state throughout his service. One problem with this approach is the fact that ATI research indicates strongly that individuals do not always learn best that which they enunciate as being most desirable to them. With that caveat, recent surveys by various Army agencies appear to

point towards a need for skill development and educational benefits to be the main reasons why a majority of young people are joining today's Army.

One such study was recently completed by the community Mental Health activity at Ft. Knox, Kentucky, which surveyed 1,068 armor trainees who underwent training during May through August 1978.[25] All individuals included in the sample were surveyed prior to undergoing basic and advanced training. Thus, their original motivations, and hence positive attitudes towards the military, were presumed to be intact. The sample was analyzed by educational level (high school vs. non-high school graduate), age, and reasons for joining. Of the 860 high school graduates in the sample, 58% reported the desire for educational benefits as their prime reason for joining, while 51% joined primarily or secondarily to "develop a special skill." The non-high school graduate joined for similar reasons; 62% stating the desire to develop skills as their primary reason for enlisting, while 61% joined for the educational benefits. Both groups revealed a strong desire to help the country. Four statements were selected as reasons for joining the Army by more than 50% of the sample studied:[26]

- I wanted to develop a special skill
- I wanted the educational benefits
- I wanted to travel
- I wanted to help the country

These data are consistent with the majority of attitudinal surveys conducted for and within the military. It doesn't take much imagination to put these data together with the results of ASVAB testing and the USAIS Reading Study to produce a picture of young people who have not previously been successful at learning who have joined the Army in order to correct their deficiencies and to acquire skills. It appears that if the Army can catch them at the beginning of their training, instructional developers can capitalize on positive motivation/attitudes to individualize instruction. Hopefully, early success in learning will have positive effects on subsequent training, discipline and retention.

- Other personality traits, singly and in combination present an essentially unfocused picture.[27]

Cognitive Styles

The term "cognitive Style" refers to patterns of information processing. Cognitive styles seem to mediate between personality variables and aptitudes as they apply to instructional strategies. Use of the term is often made to distinguish styles from abilities, although this distinction is blurred and it is difficult to determine a practical use for this concept. Two stylistic variables that appear to have promise in ATI research, however, do appear often and positively in the literature on interactions. These are "conceptual level" (CL) and field independence (FI). These "styles" seem to reflect both ability and personality. Hunt

and Sullivan [28] did early research on the CL concept.

Conceptual Level

CL is assessed by essay and sentence completion tests to determine individual levels of conceptual complexity. The complex person is believed to view his world as both differentiated and integrated. The person who perceives his world in stereotypes does not. Persons high in CL show a greater tendency to think abstractly than do lows and are generally more mature in their personal relations. They are more tolerant of stress, and thus perform under pressure. Hunt, et.al. have hypothesized that CL will interact with the structure of a task. High-CL persons are thought to do better with less structure; lows do better with more structure. Instructional variations of structure might include highly teacher centered courses versus self-pacing, teaching problem solving rules versus teaching by examples, etc. Cronbach and Snow (1977) reviewed the significant ATI research on CL and found the need to combine an analysis of academic aptitude along with CL to better explain significant ATI results.[29] This said, the research does tend to support Hunt's hypotheses that low structure instruction serves high-CL groups better and structured instruction serves low-CL groups better.[30] However, it is also noted that "...persons high in ability and low in CL did considerably

better under external direction..." than did persons high in CL and low in ability. In other words high CL cannot offset poor overall ability.[31] Once again, it is evident that general ability is a powerful predictor of learning performance and should probably be used in all aptitude constructs.

Field-Independence

The principal work on field-independence (FI) had been done by Witkin[32] and his associates. FI is usually determined by results of Embedded Figures in which the individual must detect simple geometrical figures contained within more complex figures, or performance tests such as the Rod and Frame test, in which the subject is required to directly or indirectly adjust a moveable rod to the true vertical position while the rod itself is located in a separately tilted frame. Persons able to identify a simple figure or a vertical position in a complex context are said to be field-independent or able to analyze complex situations rapidly and accurately. One who has difficulty in doing so is said to be field dependent.[33] A relatively few studies have examined the interactions of FI with instruction. These studies have found that it helps to make instruction similar in style to that of the learner. That is, if the learner is high-FI then instruction should center around discovery and application of concepts; if the learner is low-FI

then instruction should avoid dealing with concepts and should substitute the teaching of rules and procedures. However, as noted by Cronbach and Snow after a complete review of past research, there are "...enough inconsistencies to make generalization (as to the ATI of FI) impossible for the present."[34] As with conceptual level (CL), it will be essential to quantify the effects of FI in a multi-trait experiment.

ATI Testing

Instructional comparisons in the literature invariably involve measures of central tendency. This tends to weaken the effects of individual differences in learning and performance. Thus, while some students may do better with one mode of instruction while others profit more from a different mode, the use of the statistical mean tends to disguise this fact and on the average no differences between groups would be observed.

Cronbach and Snow recommend that "...ATI research use confidence limits instead of testing the null hypothesis... every report on an ATI study should carry basic descriptive statistics within each treatment. The needed statistics are the mean and Standard Deviation of each aptitude and each outcome, plus the regression slope or correlation for each aptitude-outcome pair...interactions that do not reach significance should be described along with those that do, especially in analyses with low power. Consistent non-

significant results."[35] As a minimum, a careful regression analysis of the relationship between individual differences and mode of instruction is required. The truth and importance of this lesson to researchers and instructional developers alike cannot be overstated. Time after time study results have been discounted because correlations were not significant at the p.05 level. As a result, individual aptitude treatment interactions become lost in the group statistics as researchers strive to separate the chance perturbation from solid, predictive, results. In reality, finding out what happened to an individual during instruction and reporting it is what is important. Significance testing is then of secondary importance; a useful guide, but not the final authority for separating form from substance. Also, Cronbach and Snow[36] "...take ordinal interactions (a situation where two regression slopes do not cross) seriously." And take them seriously we must, if we are to avoid losing the forest for the trees; the important thing being the amount a student or group of students improve under one or more treatments. (See Chapters II and III of Cronbach and Snow, 1977, for a complete discussion).[37]

- Most ATI research has been accomplished with too few subjects. It has been shown that researchers should employ samples of 100 subjects per treatment.[38] The numerous "no difference" and contradictory results emerging from the ATI literature are most probably the result of the lack of power resulting from small samples in regression analysis.

"As correlationists are well aware, the sampling variability of a correlation coefficient is surprisingly large relative to its range of permissible values."[39]

The reader should turn to Chapter 3 of Cronbach and Snow (1977) for a complete discussion of the inadequacies of the ANOVA for interaction research and Chapter 4 for advanced statistical analysis topics.[40] These two chapters are highly technical in nature but provide detailed guidance as to use of statistical analysis in testing. As such, they are a must for ATI researchers for use in both the test design and data analysis phases of research.

- As indicated previously, most reported ATI studies have employed treatments of short duration. This has added to other deficiencies of design, analysis and reporting to frustrate researchers and instructional developers alike.[41] Since it has been demonstrated that subjects exposed to treatments for the first time will probably differ in performance from those who are experienced with the treatment, short treatment results are often very misleading. This difference is parallel to aptitudes developed through previous learning. Under such circumstances, an interaction demonstrated early on may well be changed or even reversed in later stages. Therefore test plans must provide for a period of habituation. At the same time, because of the difficulties of transferring results from laboratory settings to natural learning situations, it is advisable to integrate ATI experiments with ongoing training.[42]

- Learning research can be designed to either hold training time constant or to allow time to vary so as to allow all students to be trained to "criterion." Research into programmed instruction is a good example of allowing time to vary by student as the measure of effectiveness is obviously time to criterion. Sounds logical. However, for ATI research there are strong reasons to recommend that ATI researchers hold time constant. This recommendation centers around the fact that how much a student learns within a specified treatment is a meaningful measure of the effectiveness of that treatment. If time is allowed to vary then it is possible that treatment A could produce better post-test scores while treatment B produces lower scores in a shorter period of time. If times and scores point in opposite directions interpretation is impossible.[42] Similar problems arise when soldiers are trained to "mastery" by being given remedial training until they are able to satisfactorily perform specified critical tasks. It is possible however, that terminal performance was not really uniform. There have been circumstances when this has been shown to be the case. This was discovered in retention testing which measured performance differences of ATI graduates subsequent to unit assignment. Loss of performance had been attributed to skill decay when in fact the skill had never been mastered.[43] Thus, an experimental design that allows time to vary cannot be said to have the compensating [illegible]tage of holding learning constant.[44]

In summary the literature reveals general ability to be the most powerful predictor of learning performance and lays out some universally applicable instructional strategies which, together with the lessons learned from pas. ATI efforts, can be used as initial ATI principles to support development of the TEA process. An excellent summary of the range of instructional strategies which can be related to individual aptitudes was prepared by the Canyon Research Group, Inc., for the U.S. Army Research Institute (ARI). This quote from their work on developing instructional alternatives for the training of Air Defense (REDEYE) gunners, is included as one of the best available.[45] (A complete discussion of this interesting study is contained in Chapter VI

> The most efficient strategy containing the greatest motivation for high aptitude learners is a non-structured individualized program. The learners in this category should be given the instructional objectives, the freedom to choose their own study method, and to pace themselves... to decide whether to work in groups or alone.... Extensive feedback and motivation are not needed, since this group provides its own intrinsic feedback and motivation.
>
> In contrast to this, low aptitude learners require complete structure with instructional sequences broken into small steps, a slow rate of presentation, high degree of repetition, elementary language level, with content presented in a functional context, and extensive practice. The presence of a live instructor to provide constant external feedback and motivation appears to be essential.
>
> Research to date has also indicated cognitive style to be an important learning variable. The extent to which an individual is analytic

or non-analytic (field independent or dependent) may affect how efficiently and effectively he/she attains certain skills and knowledge and may suggest appropriate instructional strategies, media, and methods of instruction.

The ability to provide structure and reorganize perceptual information presented as variations of a structured field can determine the effectiveness of given instructional methodology and a learner's success in mastery and retention on specific tasks. It has been hypothesized that the greater structuring capacity will enable field independents/analytics to provide their own strategies for encoding and utilizing instructional materials. Field dependents/...will be more dependent upon the instructional materials to provide structure and organization (Goodenough, 1976).

In determining appropriate strategies for either group, existing research has suggested that field dependent persons tend to: (1) learn socially relevant material more effectively; (2) prefer to assume a passive or spectator learning role; (3) are more affected by negative reinforcement; and (4) favor interactive teaching methods. The field independent person tends to: (1) assume a more active or participant learning role; (2) learn more efficiently with intrinsic motivation; (3) perform better without feedback; (4) need less external structure; and (5) favor expository teaching methods (Rosenberg, Mintz, and Clark, 1977).

In any perceptual/psychomotor task, such as the one of interest in this study, the learner's perceptual abilities have proven to be important variables in determining the level of proficiency that will be attained (Michael, Guilford, Fruchter, and Zimmerman, 1957)...

In effect, the instructional developer is led to a dichotomy. A learning strategy would appear appropriate for high-aptitude learners who are field-independent, low on anxiety and have a need for achievement thru independent action. A teaching strategy seems to be the more useful approach for low-aptitude learners who are field-dependent and high on measures of defensiveness such as anxiety.

The teaching strategy implicitly encourages rote memorization leading to information storage which may not get meaningfully related to other stored material. Such a strategy, although obviously useful in the Army's present training situation, is likely to prove maladaptive in many combat situations where understanding may be far more important than mere performance of a limited number of critical tasks. By training low ability soldiers by means of teacher oriented strategies the Army, in essence, may discourage a soldier from developing an awareness of his cognitive capabilities: capabilities that must be developed if the soldier is ever to grow into the higher skill level tasks required of noncommissioned officers. This is not to suggest that ATI results demonstrating the need for teacher centered instructional strategies are inappropriate. Rather, it suggests a more complex learning strategy is also needed to develop the individual's cognitive abilities to facilitate the transfer of acquired skills later in his service. This is one reason why TEA is so important. TEA provides the Army with a methodology for developing instructional strategies of the requisite complexity needed to develop the young civilian into the trained, mature, skilled soldier.

Chapter Summary

To briefly sum up. The view emerging from the literature as regards aptitude interaction with instructional strategy is that the individual must be viewed as a being

shaped by the interplay of his genetic structure and experiences. For this reason research strategies must provide for the analysis of information processing and cultural/personality differences, as well as general and special abilities. The importance of this perspective cannot be overstated as this allows researchers to carry measures of these aptitudes through their studies. Since the literature is much less clear as to the power of such variables as creative thinking, impulsiveness, cognitive complexity and other constructs to interact with treatments,and because reliable tests are less available to measure these constructs, research into their effects should be carried on separately, apace with ATI research so as not to impede progress while seeking additional information.

CHAPTER V

RESEARCH METHODOLOGY

Identification of the general results of diverse studies on aptitude-treatment interactions is useful as background information but does not provide guidance adequate for the analyst attempting to continue ATI research within the context of TEA. What is needed is a theory or model of the learning process that provides a framework for the collection of data on aptitudes and treatment interactions and can be used by the instructional developer in the design and revision of training. The theories and methodological concepts needed by the researcher are now available. Many leading psychologists are now working on these problems. Glaser (1976), Cronbach and Snow (1977), Hunt (1977), Greeno (1977), Sternberg (1977), Resnich (1976), Gagne (1968, 1970), and many more, have made significant contributions. A complete discussion of all these important efforts is impossible in a short research paper. Although only an outline and summary of the most applicable concepts about individual differences can be presented here, it is necessary at least to generate hypotheses about the cognitive processes that distinguish aptitude constructs. Further, it should be recognized that all relevant concepts and methods will need to be combined if ATI theory is to be useful in improving soldier training.

Because general abilities are known to interact most often and strongly with instructional treatments, this aspect of individual differences would seem to be the most logical starting point from which to construct a research theory.

<u>General Mental Abilities</u>

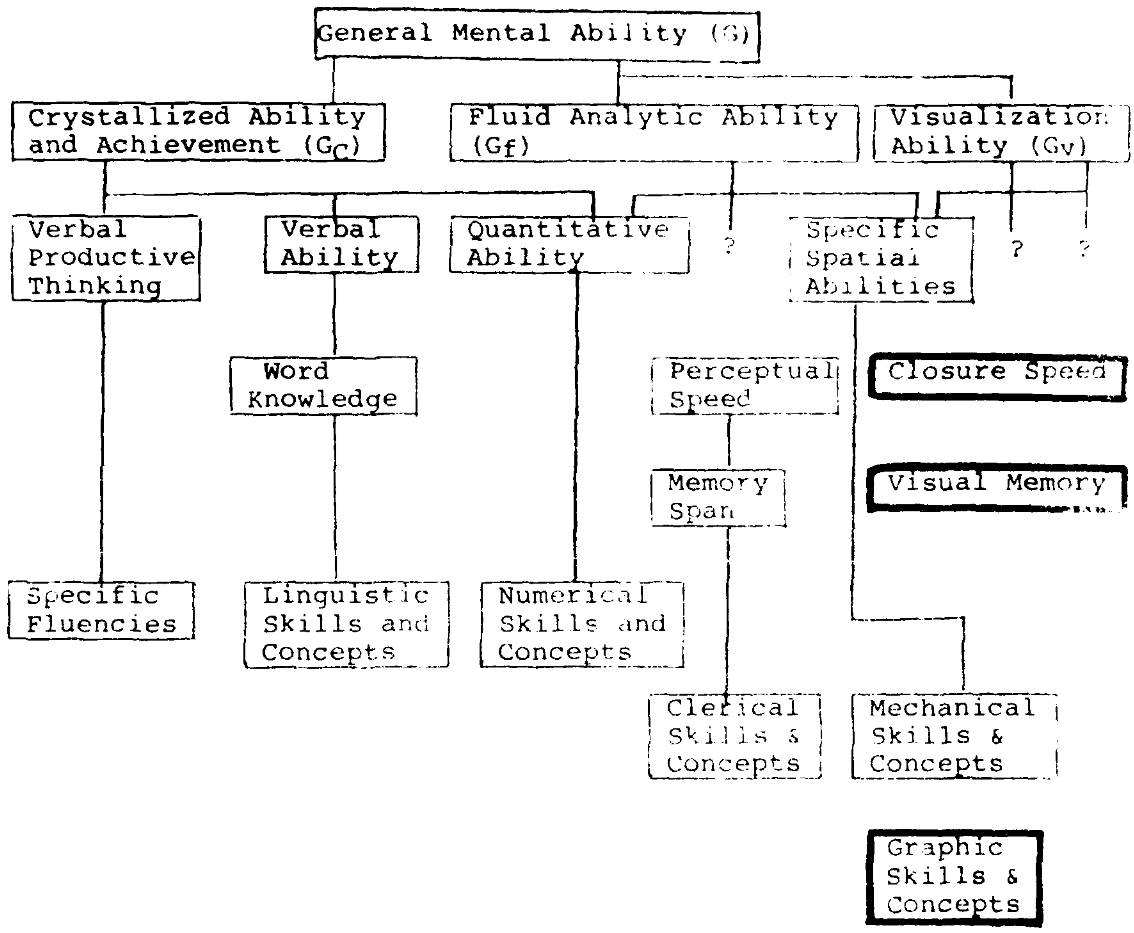
Berliner and Cohen have discussed the problem of general intelligence (G), and suggest that many instructional situations require such a high level of general intelligence that little variance remains after the effect of general intelligence is removed. For this reason they believe interactions of G with instruction are difficult to detect. They urge discovery of treatments that do not rely on general intelligence.[1] McKeachie[2] and Glaser[3] would apparently agree; both seeking "new aptitudes" conceptualized in terms of the processes needed to perform given tasks. Researchers such as Hunt (1973) have conceptualized learner characteristics in terms of "accessibility" translatable into specific forms of educational environments. Hunt envisions learner profiles in terms that describe a specific orientation as: (1) cognitive orientation; (2) motivation orientation; (3) value orientation; (4) sensory orientation.[4] His idea being that these "accessibility characteristics" provide a means of tailoring instruction to an individual's orientations.

These approaches present several problems, however. First of all, very little work has been done on other than the cognitive processes. Secondly, general mental ability

measures are available for use and have been shown to interact with identifiable instructional treatments and, to a lesser extent, with personality variables more reliably and often than have special abilities and aptitudes. Lastly, such characteristics as motivation and values, or even sensory orientation, are more likely to be transitory in nature and to be overwhelmed by general ability given a positive motivation. This suggests that what is needed is a way to define and model general intelligence in such a manner that it is compatible with information processing models. In other words, we need valid terms of reference to describe what happens during an instructional event. Snow has provided an excellent theory of general intelligence and linked it to a research framework which serves to combine other relevant information processing concepts.[5] Snow's work is useful precisely because he has brought the research results of others into a cohesive framework. His paper, entitled "Theory and Method for Research on Aptitude Processes: A Prospectus," is particularly suitable for use as a TEA research construct for the development of soldier profiles as they relate to training. Figure 6 shows a structure designed by Snow to "approximate those fashioned by Vernon (1965), Cattel (1971), and Cronbach (1970), and to be consistent with Guttman's (1965) multidimensional scaling of Thurstones data...."[6]

FIGURE 6

HIERARCHIAL ORGANIZATION OF ABILITIES



This hierarchical construct provides a framework on which can be placed many of the separate aptitudes and differences discussed in Chapter IV. For a full discussion of Snow's approach the reader should consult the primary source.

General mental ability is divided into three major subdivisions: Fluid analytic ability (G_f), crystallized verbal ability and educational achievements (G_c), and visualization ability (G_v).[7] As can be seen by a review of the ASVAB/AFQT subtests at Appendix I, spatial abilities are also categorized as a component of general mental ability by the military. This is consistent with the literature (Horn, 1976), and is one element represented by visualization (G_v). Other subdivisions of G_v are, however, unknown at this time. Below these, Snow has placed more specific abilities and skills as subordinate, but inclusive of, general abilities. By comparing the elements included on the ASVAB with Figure 6 it can be readily seen that many reliable measures of general ability are already to the TEA analyst. There are, however, more data supporting the crystallized ability and achievement side of the hierarchy than are available for either fluid or visualization abilities (G_f and G_v). This is reflected by the question marks, dashed lines, and the unconnected perceptual speed and memory span boxes in Figure 6. This suggests, of course, that future research should focus on the G_f and G_v aspects of G;

a task more appropriate for ARI than for TRASANA, but necessary for the mature TEA. As concluded in the Chapter IV summary of the Literature, ATI researchers should deal with as few aptitude variables as possible and should allow additional ones only as demanded by the data. The hierarchical organization of aptitudes in Figure 6 assists the researcher in this regard as one need not interpret an interaction in terms of a special ability unless it can be shown that a more general mental ability does not account for the result. Snow's hypothesis concerning this hierarchy is that:

> ...the vertical dimension...represents differences in reference generality among ability constructs. Constructs at higher levels typically refer to higher classifications of tasks...that are likely to transfer to...a broader range of intelligence measures.

A compilation of the varied definitions of major human abilities portrayed in Figure 6 is to be found in Appendix II.

By starting with the hierarchy in Figure 6 it appears that the researcher has a foundation upon which to build his initial framework that has not been provided elsewhere.

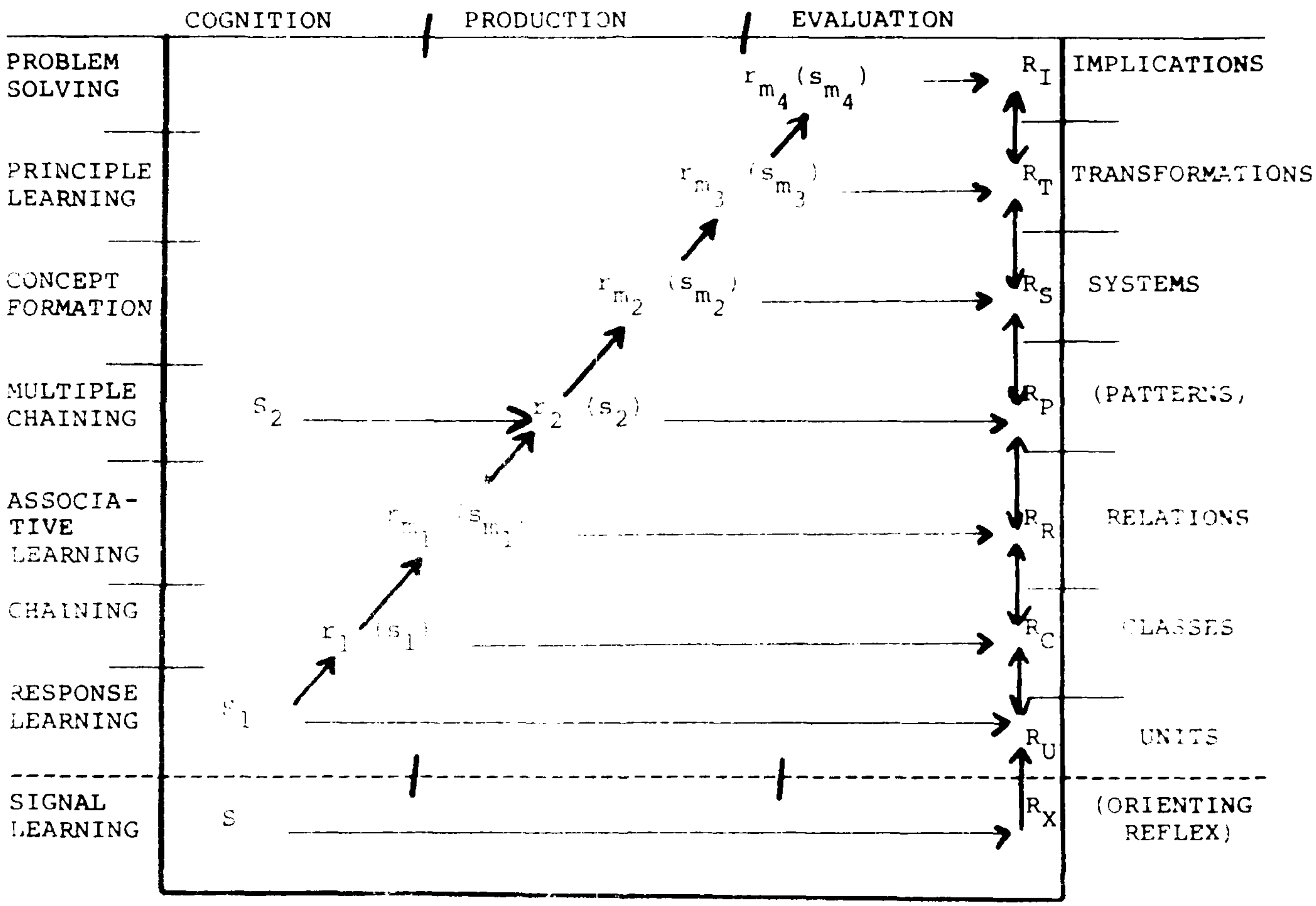
The next step would logically appear to be to build on this general abilities model in two ways:

a. Additional laboratory research is needed to develop fully the range and scope of the G_f and G_v subelements, and their relation to other G constructs.

b. A theory is needed to connect the hierarchical model of G with a concept of information processing to answer the question as to how an individual uses his general abilities to translate instruction (stimulus) into performance (response). The first requirement is beyond the scope of this paper as it will require extensive long range research. The second requirement has in fact been largely accomplished. Snow has synthesized the works of numerous researchers to link the gross concept of stimulus-response into a transformational schema,which not only builds on the concept of "G" shown in Figure 6, but also provides a framework for testing and evaluation which should be useful in TEA. While lacking precision and oversimplified, this schema maps the transformation into three hypothetical phases: (1) Cognition, i.e., discovery of new information through the stimulus of learning; (2) Production, i.e., thinking in terms of patterns, systems, and transformations; and (3) Evaluation of the implications and adequacy of possible responses. By synthesizing this concept of the stimulus-response theory with the hierarchy of general ability, the researcher can construct a hierarchical learning taxonomy useful for designing ATI experiments and data evaluation. Figure 7, Snow's schematic coordination of learning and ability hierarchies provides such a taxonomy. In Snow's words:

FIGURE 7

SCHEMATIC COORDINATION OF LEARNING AND ABILITY HIERARCHIES



> The ordering of steps implies further that abilities representing these operations product cells...both reflect prior learning up to the associated...level and predict individual differences in new learning at those levels. One could imagine the design of learning tasks to represent several adjacent levels or stages of learning and their use in research aimed at correlating individual differences in learning at each level with ability tests chosen from the corresponding response product hierarchy. The hypotheses would be that measures of general ability would correlate with learning in all stages, if the task began at the simple response learning level. Specific tests chosen to represent particular products would correlate primarily with performance at the associated learning level.[10]

Chapter 5 of Cronbach and Snow's "Aptitudes and Instructional Methods" had a discussion of the few studies which have tested this type hypothesis.[11]

While research is necessary to validate and refine these levels of learning, they do provide a framework for continuing ATI research that is superior to that found elsewhere in the literature. The hierarchy in Figure 7 provides a continuum of increasing complexity in learning and ability which facilitates conceptions of the learning process and allows the ATI researcher to continue to build a test methodology. The simplest ability tests and learning tasks involve understanding of units, classes, and relations. The more complex tasks involve the skills associated with the understanding of systems, transformations into new tasks/skills and the evaluation of implications being the most complex.[12]

This is consistent with what has been established in the literature concerning high versus low general abilities and provides a needed link between "G" and performance as a result of learning.

While Snow (1977) admits this is now all "mere speculation" the construct is compelling precisely because it is consistent with trends established in ATI research and, dare it be said, it is intuitively satisfying in that it corresponds with the common knowledge of the existence of a hierarchy of difficulty in learning and real life tasks.[13]

A Stimulus-Response-Response (S-R-R) Pattern

Mention has been made of the well established stimulus-Response theory. If the concept of learning in Figure 7 has validity however, an intervening response, conditioned by individual differences, is to be expected. That is to say that a psychological theory linking a stimulus to a behavioral response should encompass the process believed to occur within the individual. As an example, if a student must translate numbers or figures into concepts before he can react appropriately to a stimulus, then complex or poorly organized numbers or figures will take longer to translate and will likely be incompletely conceptualized under conditions of short exposure or reaction time. The degreee of concept completion--the middle R--can then be thought of as a cognitive aptitude which differs among individuals. Snow makes this

point in proposing a Stimulus-Response-Response model for research on individual differences in psychological processes. This S-R-R model is necessary if efficient use is to be made of what is known about information processing because it provides the link between the hierarchy of learning and ability in Figure 7 and useable information processing concepts necessary to develop instructional strategies for specific groups of individuals.[14]

Snow points out that for research on individual differences in psychological processes the two response variables must be measures applied to the same subjects which yield individual scores for each subject. He states the S-R-R paradigm succinctly as:[15]

> ...effects of experimental manipulation... are reflected in changes in the R-R interrelations as well as the mean of each R. The middle R might be truely an intermediate response measure in an experiment, or it might be a measure of an individual attribute taken before the occurrence of S. (before the training). All experiments on ATI are instances of the latter type. The aptitude, while measured before treatment, is presumed to represent individual differences on an intervening variable essential for learning.

The utility of this construct for ATI research and the TEA analyst is obvious. If the manner in which an individual processes stimulus information is a predictable variable reflecting aptitude and if the ultimate performance (the

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second "R") is dependent on these differences, the concept of ATI is not only reinforced but an experimental methodology applicable to TEA goals and objectives is also indicated.

Information Processing

Information processing models are increasingly important to the psychology of human learning. These models, largely supported by computers, provide a basis for increased knowledge as to the complex cognitive processes connecting stimulus and response. The literature on information processing is both complex and lengthy and a detailed discussion is beyond the scope of this paper. However, an adequate information processing model is essential to a well designed ATI experiment if an interaction between aptitudes and instructional treatments is to be made. Bower (1975) provides an outline of the major elements of most information processing models.[16] Snow (1976) uses this as a framework within which to consider individual differences in information processing. Bower begins by making a distinction between the initial perception system, short term memory (STM), intermediate memory (working memory) (ITM) and long term memory (LTM). Within these are assumed to be subroutines to detect, analyze and evaluate incoming information in order to recognize patterns and to add previous knowledge to new information. The theory is that STM maintains the spatial and temporal order of the information

and categorizes and relates groupings of data. Thus, the STM allows the individual to react rapidly to information conveyed by the eyes, ears, nose, etc. However, since STM does not store information, people use the ITM to maintain data concerning the task setting and local environment within which the overall activity is taking place. ITM maintains the ongoing situation in a coherent manner while STM is actively engaged in learning/performing. LTM is the site of storage for permanent knowledge, concepts, attitudes and skills. Data are withdrawn from LTM to update/improve more limited data available in ITM and to improve the quality of the overall problem solving performance.

As portrayed in Figure 7, tasks are believed to differ in their complexity. Snow (1977) has translated the implications of Figure 7 into information processing terms and added Bower's concepts of STM, ITM and LTM to analyze learning, ability and problem solving. The hypothesis is that individual differences in information processing are at the heart of observable differences in learning. Because no simple list of standard differences or measures of differences are likely to be generalized across the population or to remain static over time, it appears necessary to establish difference sources and kinds of individual differences in information processing and to show how they can be combined and/or further differentiated so as to determine how they work in combination to produce differences in performance resulting from distinct instructional treatments.[17]

As discussed in Chapter IV there is evidence that familiarization alters individual differences in learning and that various personality and motivational factors tend to modify the role of ability in learning. Further, as Snow points out, measures of individual differences may be relatively unimportant in simple learning and become highly important and intercorrelated in more complex learning. People may also differ in the sequence each uses to accomplish a common set of information processing steps, or may differ in the routes or alternatives they choose to employ to process the data.[18]

To keep these logical possibilities distinct, the use of four different sources of differences in information processing appears to be necessary. These are:[19]

- Parameter differences (P-variables) which refer to differences on particular steps of components such as capacities of STM, times needed to process information, amount and quality of information in the LTM, etc.

- Sequence differences (Q-variables) which refer to individuals taking the same steps but in different sequence.

- Route differences (R-variables) which are indicated by qualitatively different steps taken such as double checking the data, use of audio derived data in preference to visual, etc.

• Strategic differences (S-variables) represent individual differences in complex learning and problem solving. This category would include large differences in assembly and structure of memory and programs. The S-category is necessary to account for themyriad complex differences known to be present in learning and which cannot be accounted for by the simpler variables of P, Q, and R.

In their work, Newell and Simon have developed some definitive statements about the kinds of individual differences found in the processing of complex information. Snow has paraphrased their observations as follows:[20]

> 1. Subjects differ in the detailed contents of LTM when beginning a problem. This places constraints on the problem spaces and programs available for use.
>
> 2. Subjects differ in the way they characterize the initial problem. They learn gradually which aspects of the problem should be given first priority and which can be ignored.
>
> 3. Subjects differ in persistence in pursuing a subgoal and, conversely, in their readiness to return to the overall problem in pursuing a complete solution.
>
> 4. Subjects differ in the priority given to restructuring the problem as information is acquired as opposed to working in the framework of a definite plan.
>
> 5. Subjects differ in the cues used to detect lack of progress toward a goal.
>
> 6. Subjects differ in trying to explore paths mentally, as opposed to writing out expressions for examination.

7. Subjects differ in the degree to which operational rules are associated directly with problem features, reducing the need for searches to find appropriate rules.

8. Subjects differ in acquiring knowledge that certain features are not remediable, indicating termination of search, while other goals are automatically achieved by fixed sequences.

These kinds of differences suggest the possibility of adapting instruction to suit specific situations resulting from the interaction between individual information processing differences, task complexity and type, personality variables and instructional environment differences. Snow goes on to observe:[21]

> Thus the problem for further research will be to distinguish P, Q, R, and S sources of individual differences, and to show how they can be combined and/or further differentiated. Information processing models of particular tasks or tests will need to show how these kinds of differences work in consort to produce observable differences in performance. Aptitude variables (A), and instructional treatment variables (T), and their interactions will need to be analyzed and understood in these common terms. This will best be accomplished by a combination of Q, R, and S variables, and experimental research that manipulates T in ways that influence these relationships. This suggests...the value of an elaborated S-R-R paradigm.

Some ways in which treatment may be related to strengths and weaknesses in information processing are suggested in the literature. Salomon (1972) and Cronbach and Snow (1977) have discussed alternate models that are defined by the manner in which treatments are used. These models are:[22]

- The preferential model, which capitalizes on the learners assets.

- The compensatory model which provides compensation for learner weaknesses.

- The remedial model, which attempts to overcome some deficiency in the learner. Since proficiency in a specific task may depend on how well the basic information process and relevant knowledge have been organized into an effective program,it is useful to think of the above differences in terms of these corrective treatment models.

A review of the literature reveals concepts that are supportive of the S-R-R and information processing models and which reinforce the conclusion that these combined theories are likely to be productive in ATI research. DiVesta[23] stresses that ATI studies would be more productive if cognitive processes were considered which correlate with traits induced by instructional treatments, and Shapiro identifies three distinct concepts of mental ability differences which could be used in testing aptitudes.[24]

- General mental ability.

- Finer distinctions such as those considered in models such as Guilfords' Structure of the Intellect and hierarchical models in which general ability underlies more restricted abilities.

- Problem solving approaches (mental processing, perceiving, coding, storing and retrieving information.

Gagne (1974) presents a classification scheme consisting of five categories: (1) verbal information, (2) motor skills, (3) intellectual skills, (4) attitudes, and (5) cognitive strategies.[25] These concepts are compatible with Snow's theories and add to the credibility of his constructs which have been paraphrased above.

Before formulating a more detailed research strategy for use in the TEA process, it may be useful to outline how some useable personality variables may be combined to predict learning performance and to summarize what has been suggested so far.

Personality Variables

As discussed in the summary review of the literature in Chapter IV, variables such as anxiety (A_x), and need for achievement (Ach), have been shown to interact with instructional treatments and appear also to combine with one another and/or with General Mental Ability in higher order ATI. While much is to be learned as to useful categorizations of personality variables, the above factors appear to interact with instructional treatments more strongly and often than others and should logically be included in ATI research aptitude constructs. The combination of these variables is dependent on the trainee population. That is to say while need for achievement has been shown to combine with trait anxiety to form a more powerful predictor, both the strength

of the combination and its direction are individually determined. For a complete discussion as to the effects of these variables, separately or in combination, the reader should turn to Chapters 12 and 13 of Cronbach and Snow's "Aptitudes and Instructional Methods."[26] Although the final conclusion must remain that the nature of the interaction of these variables is complex and yet to be defined fully, their inclusion in ATI research through the medium of TEA will provide a greater measure of the percentage of the differences in individual aptitude and performance than would otherwise be attainable.

Ability Constructs

Certain ability differences have also been identified with concepts of information processing and should be included in the aptitude construct. Some of these abilities unfortunately, are also those for which measurement instruments are not yet developed fully. As shown on Figure 6, however, ability constructs relating to perceptual speed, closure speed, visual memory, and memory span, as well as the various cognitive style constructs comprising crystalized ability and achievement (verbal, numerical, and mechanical skills, etc.), should eventually be included as they relate to the task characteristics being taught. The reader should recognize however that this will require additional

research before operational use can reasonably be expected in the TEA process.

Task Analysis

Having developed an aptitude construct or constructs, it becomes extremely important to complete an accurate analysis of the task to be trained. It is crucial to develop a listing of component student behaviors expected as the end result of training. Phase I of the ISD process used by all military services, provides for the compilation of an inventory of job tasks to be trained and for a determination of job performance measures. As a final step the list of tasks selected for instruction is to be analyzed to determine the most suitable instructional setting for each task.[27]

However, there does not now seem to be any one best way to gain detailed knowledge about the processes to be expected in task performance. In fact one of the most important tasks of the TEA program should be to validate, refine and standardize task analysis procedures.

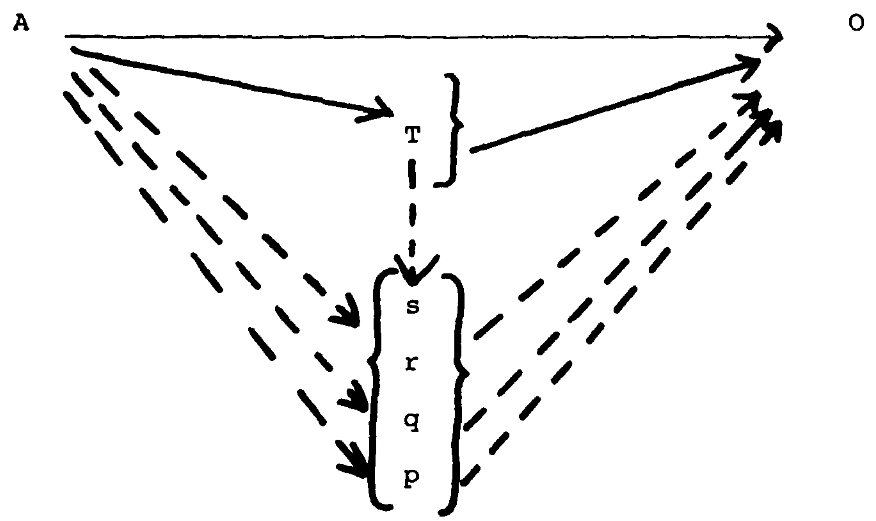
A Synthesis

The next logical step is to develop a means of correlating the relationship between the aptitude constructs that have been suggested and the various treatments that can be designed by making full use of procedures that have been established by trial and error in prior ATI studies. It

is suggested that this be done within an analytical framework of the information processing model. Snow (1977) has proposed a theoretical framework for doing this. Figure 8 shows the categories of variables that have been identified and indicates by arrows the direction analysis should take.

FIGURE 8

SCHEMATIC REPRESENTATION OF STANDING CORRELATIONS BETWEEN APTITUDE (A) AND OUTCOME (O) VARIABLES, A x TREATMENT (T) INTERACTIONS, AND THE ANALYSIS OF A AND T VARIABLES INTO INFORMATION PROCESSING VARIABLES, BRACKETS INDICATE COMPLEX INTERACTION.



s = strategy
r = route
p = parameter
q = sequences

Snow explains his theoretical framework in these terms:[28]

> Standing predictive relationships between aptitude variables (A) and learning outcomes (O) from instruction have been shown to be moderated by instructional treatment variables (T), with the recognition that ATI often occurs. It is clear that AT combinations can be studied in real instructional settings, and should continue to be, but that this research must be supplemented by analyses conducted in laboratory settings where there is more chance of building theoretical models of psychological processes operating in ATI. The cognitive information processing approach of modern experimental psychology seems best equipped to guide and inform such analyses. But computer simulations and related work already completed show that individual differences in these aptitude processes probably take a variety of complex forms. A distinction among four major forms or sources of apparent individual differences in processing should help to unravel these aptitude complexes. It appears that individuals can differ in parameters(p) reflecting efficiency and capacity in particular processing steps or components, in how a sequence (q) of processing components is organized, in the inclusion of different components or processing routes (r), and in the overall summation (s) of assembly and adaptation of processing to particular tasks.

Researchers making use of this framework should conduct their investigations within the stimulus-response-response model (S-R-R) wherein "stimulus conditions are manipulated to test R-R relations by controlling or modifying them."[29] Snow (1977) cautions that adequate theory will have to be built on this combined S-R-R/information processing theory. The literature bears witness that this is true. Requirements to establish the validity of these constructs make inclusion

of a representative set of these factors in the analysis process a necessity to ensure the attainment of the requisite scientific rigor.

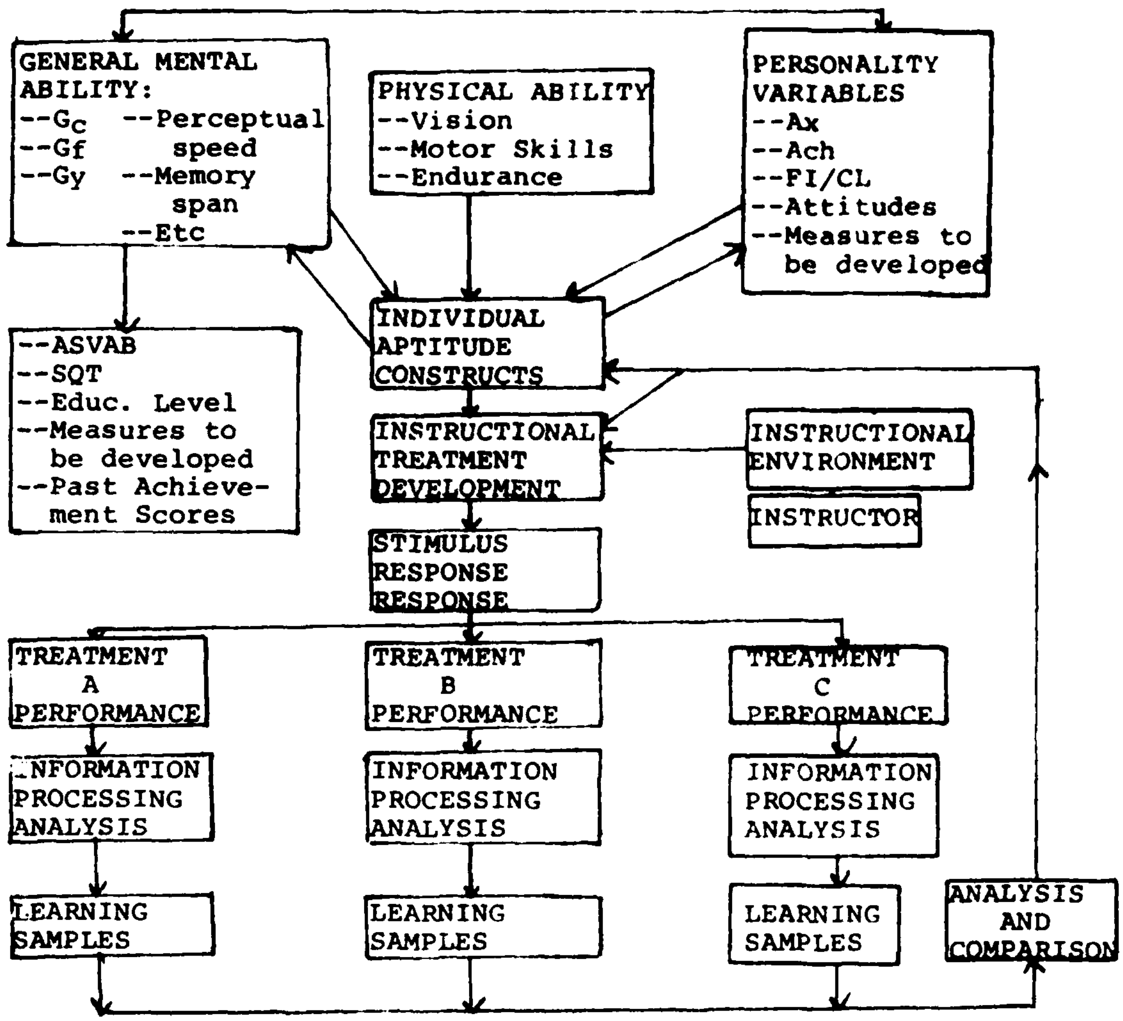
Summary

The aptitude process analyses discussed in this Chapter are most likely to be predictive if linked to instructional alternatives on the basis of the predictive power of aptitude-instructional interaction (ATI) theory. This process is portrayed in Figure 9,a general methodology construct.

Figure 9 depicts graphically that the ATI researcher should start with the evelopment of aptitude constructs to cluster his student population into groups of hypothetically similar aptitudes. Beginning with general mental abilities, he should add appropriate elements of personality variables and physical ability measures (persons without death perception should *not* be trained as tank drivers, etc.). To these factors should be added measures of prior achievement such as SQT scores and educational levels and cognitive style such as measures of field dependence and concept level to construct a profile of the soldier to be trained. Turning to the ATI literature, a tentative hypothesis should be formulated as to how the individual profile is expected to interact with instructional treatments

FIGURE 9

GENERAL METHODOLOGY CONSTRUCT



(high-ability, Ach i, low-A_x students do best with self-paced instruction, low-ability, low Ach, high-A_x students do best in a teacher dominated, structured, training environment, etc). After clustering his population by aptitude, and previous learning (i.e. trained mechanics should score high on the MM subtest of the ASVAB and should acquire new skills at a greater rate than others also scoring high on the MM subtest) a task analysis is made of the tasks to be trained in accordance with the ISD model. Instructional treatments should then be developed in accordance with the ISD model, Phases II-IV (Design, Develop, Implement). It should be noted in passing that Phases II-IV of the ISD model already require an analysis of basic aptitudes and abilities and direct that course designs be based on these aptitudes.

However, it is at the beginning of Phase III, development, that the analyst should make maximum use of the knowledge to be gained through the ATI research process to better implement the requirements of ISD. In determining how the instruction is to be packaged and presented to the student, full use should be made of the concepts of matching such factors as the media, training setting and instructor to the students, who have been grouped by aptitudes. It is entirely possible, by the way, that given how little is known about ATI interactions, a large percentage of the

student population will not be amenable to groups on the basis of a homogenous aptitude. It is suggested that these students, for want of a better solution, be trained by an entirely conventional program developed without the aid of ATI research derived insights, and that this treatment be used by the researchers for control purposes.

Once the treatments have been developed, the ATI evaluation plan should be structured around the S-R-R model and student learning analysed in terms of the information processing model. It is at this point that the process analysis of aptitudes should be brought together with the comparable analysis of instructional treatments. Combined assumptions and hypotheses should be scrutinized for validity by tracing components of the aptitude profiles through to individual differences in learning resulting from the alternative treatments. Extensive use should be made at this time of the statistical techniques outlined in Chapters 3 and 4 by Cronbach and Snow (1977), emphasizing the language of the multiple regression analysis to document aptitude and treatment interactions. Because many of the necessary aptitude measures will have to be developed apace with the test program,it is likely that feedback to the individual aptitude construct procedures and to the instructional development process will result from an analysis and comparison of the relative treatments.

Two notes of caution appear to be warranted here. First, researchers should take extensive precautions against the possibility that the "Hawthorne effect" will skew their data. As noted previously, students do adjust to different treatments--they are likely also to adjust in novel ways if they are aware that they are part of an experimental (special?) group. For this reason all aptitude groups must not only be given a chance to habituate to the instructional strategy; they must also be led to believe that they are undergoing routine instruction. Second, the control group may no longer represent a normal population once those grouped by aptitude categories have been removed. This suggests that it may be wise to carefully screen control group members, adding select personnel as necessary, to ensure a normal representation of the target population.

CHAPTER VI

AN IMPLEMENTING STRATEGY

To this point the research has highlighted the need and feasibility of establishing alternative instructional strategies for training entry level soldiers to improve job performance. It is evident that to be acceptable an implementing strategy must be as simple as possible, make maximum use of existing training and personnel testing procedures and be achievable within existing resource constraints.

An Approach to Testing

A four-phase approach to field testing during TEA appears appropriate.

- Phase I. Efforts during this phase should be devoted to: (1) the identification and analysis of the tasks to be trained in accordance with the ISD model, in coordination with the appropriate TRADOC school for fielded systems and the TRADOC Systems Manager (TSM), DARCOM Project Manager (PM), and the Operational and Test Evaluation Agency (OTEA) for developing systems; (2) definition of probable target audience aptitudes, and identification of aptitude measures; (3) the development of initial instructional treatments keyed to the aptitude profiles; and (4) refinement of the combined S-R-R/information processing models

to ensure the appropriateness of aptitude measures and data collection instruments.

- <u>Phase II</u>. Phase II should be devoted to the refinement of instructional strategies; development of instruction treatment materials; the grouping of personnel to be trained by aptitude constructs and an initial determination of the terminal performance of different aptitude-treatments on tasks developed in Phase I. It is expected that instructional strategies will be driven by both the aptitude profiles and the task analysis, and thus cannot be predicted in the abstract. However, three broad types of treatment strategies are available for implementation. Which strategy or strategies are actually developed depends on the actual aptitude grouping and the characteristics of the tasks retained for teaching. A control group strategy is probably necessary during research or validation phases. The treatment strategies should be modeled after the Solomon (1972) and Cronbach and Snow (1977) models outlined in Chapter V. Of course, to more precisely focus on aptitude groupings within the student population, several variations of specific instructional strategies may be necessary within each broad strategy. Although these models were introduced in Chapter V, it appears appropriate to discuss them in more detail now so as to set the stage for the discussion to follow.

- The preferential model contains treatments that capitalize on student strengths by matching requirements of the treatment to the learner's higher aptitudes. As an example, learners with high AFQT scores would normally be high in G_C, Gf, and G_V abilities. A learning strategy for them would logically stress word knowledge, spatial relations and dealing with concepts in a relatively self-paced course. Such a strategy would be particularly appropriate if they were also high on a motivation construct featuring achievement thru independence, were field-independent, and were low on anxiety measures, that is to say they were constructively motivated and non-defensive.

- The compensatory model should contain treatments designed to overcome learning deficiencies to circumvent the disabling effects of specific deficiencies. For example, learners with low AFQT scores would probably lack reading, word knowledge and arithmetic skills. A learning strategy for these soldiers might center around media treatments featuring extensive use of audio-visual aids and be teacher centered/dominated, stressing oral presentation of lessons, in small steps with frequent review of the <u>same type</u> information given to the soldier trained by the preferential strategy. This would be particularly applicable when teaching low-ablity soldiers who lack a positive self-image who are also found to be field-dependent.

- The remedial strategy contains treatments designed to overcome deficiencies in prerequisite knowledge. Learners with language, arithmetic or general education deficiencies will probably respond best to a learning strategy that addresses the deficiency within a context of the specific tasks being taught. In this sense this learning strategy would require not only different media and materials but may actually require the teaching of distinctly different tasks which must be mastered as a prerequisite to successful learning of the primary tasks.

- Phase III is the actual conduct of the research as a part of the TEA process. This phase entails the conduct of the training, to include necessary pre-tests and post-tests and the collection of necessary data. Care must be taken to control the instruction by ensuring lesson plan fidelity, student attendance and participation, interrater reliability and maintenance of an instructional environment conducive to learning. While these conditions may not prevail at all times in "the real world" they are necessary for ATI research. To allow uncontrolled variables to be present in the instructional setting is to make accurate analysis impossible. In this regard the reader is asked to recall the HUMRRO experiment in developing the potential of low ability personnel. A structured learning strategy must be just that. It must be structured wherein

students complete all learning requirements and it must be teacher-centered in that learners devote their efforts to that which the teacher directs.

- The control strategy should be used to train those students who, by virtue of the lack of precise aptitude constructs, cannot be grouped by learning style. This strategy should be the one that would have been used had there been no TEA/ATI program. This strategy serves three important purposes: (1) it provides training for soldiers not otherwise in a definable aptitude grouping; (2) it provides a baseline against which to contrast skill acquisition gains of the other three strategies; and (3) it helps the researcher hold time constant, a necessary precaution if reliable interaction results are to be obtained.

- Phase IV is simply the data analysis and feedback phase. Data analysis requires advanced statistical techniques which are beyond the scope of this paper.

A detailed presentation as to generalized regression analysis and advanced statistical techniques appropriate for use in ATI research can be found in Cronbach and Snow, (1977) Chapters 3 and 4. Their discussion on use of gain scores as the dependent variable, improving the interpretation of ANOVA, and appropriate confidence levels for regression effects would appear to be of special benefit to analysts seeking to verify the validity of aptitude-treatment

interactions.[1] Here, only a general statistical analysis process can be suggested. A progression of analyses would seem to be necessary in most cases. This progression would likely be: (1) analysis of the data gathered in Phase I to develop a correlation matrix of all the variables of aptitude measures and critical task performance requirements; (2) a multiple regression analysis of all the independent and dependent variables is the next logical step. Independent variables would include the group aptitude measures and the dependent variables would be the terminal performance data gathered during training. These data would, of course, be grouped by aptitude composite and instructional treatment. Multiple regression analysis should be used to determine how much of the variance in the terminal performance (dependent variables) was explained by the various aptitude composites (independent variables) in different combinations. Variables (aptitude constructs) that do not account for significant amounts of variance in terminal performance should be eliminated from further consideration. Verification of the results of the multiple regression analyses by use of a discriminant analysis is necessary to focus on those aptitude constructs that will reliably discriminate within treatments between those soldiers obtaining high scores and those obtaining low scores on the terminal performance measures. Care must be taken to select an appropriate statistical method when performing the discriminant

analysis. The basic question is to what degree do differences between the treatments and/or aptitude groups contribute to terminal performance? Analysis of variance methods (ANOVA), while less powerful than regression analysis, are designed to handle this type of analysis and thus the researcher would normally turn to ANOVA techniques to answer the question. However, Cronbach and Snow have shown that associating confidence limits with regression lines provides the most satisfactory form of statistical rigor in ATI research.[2] The lack of success reported in ATI studies making use of ANOVA techniques is frequent and the knowledge gained by Cronbach and Snow in reevaluating the same studies by use of the regression analysis tends to give validity to this belief. Therefore, it is suggested that regression analysis is the appropriate language to use in describing patterns of significant and non-significant effects of the treatments and aptitudes as they relate to the terminal performance measure.

The analysis of trainee performance must be used to both refine aptitude measures and treatments. Hopefully this will lead to a definition of aptitude with two or more aptitude measures that reliably relate to job or task performance and interact positively with specific instructional strategies. By successive refinement, it should be possible to establish whether the aptitude groups defined in a task specific study exist in other parts or all of the Army trainee population. If so, then ATI research techniques

can be generalized within the Army training system through the use of TEA process.

To summarize briefly, to determine the soldier's individual learning style the TEA analyst must first develop measures of an aptitude construct that have validity in relation to the task being taught. Variables composing the aptitude construct should be as few as necessary to differentiate within treatments between students as to attainment of terminal performance objectives. Experience to date has demonstrated the variables in Figure 9, A General Methodology Construct to be the most promising, (general mental abilities; cognitive style personality variables, and physical abilities). Instructional treatment development should be guided by the knowledge gained in prior studies with regard to how students learn best in terms of learning processes-independent study, lecture, visual presentation, etc., in consonance with the three instructional strategy models; preferential, compensatory, and remedial.

Data gathered should be analyzed in terms of the combined S-R-R/information processing model using the language of the regression analysis. The results of the experiment should be used in the feedback process to identify clusters of relationships within the intended student population to designate alternative training subsystems.

An Example

It is realized that ATI techniques may be considered too exotic for use in a military training system. However, that such may not be the case has been demonstrated by the successful application of an ATI research project by the Canyon Research Group, Inc., working under contract to ARI to improve REDEYE gunner performance at the U.S. Army Air Defense Center, at Ft. Bliss, Texas.[3] Canyon Research conducted a program to investigate the effects of various instructional strategies on REDEYE gunner skills across individuals varying in measures of academic aptitude. The original hypotheses for this investigation was that an analysis of the cognitive processes and/or perceptual precesses in operation during terminal performance actions would provide a sound basis upon which to develop instructional strategies. While this study used specific perceptual/psychomotor tasks with relatively low cognitive demand as the criterion skill to be learned, and was limited in the design factors used to develop the alternate instructional strategies, it did demonstrate the usefulness of ATI research techniques in improving soldier training and performance.

This study is important because the researchers made extensive use of the ATI work of Cronbach and Snow (1977), DiVesta (1975), Gagne (1977), Sal[illegible] (1972), Shapiro (1975),

Snow (1977), and others within a framework of early TRASANA TEA efforts on REDEYE training effectiveness. In other words, Canyon Research has attempted much of what this research paper suggests as being necessary to improve training. The study concluded that:

- The use of Aptitude Group profiles in developing instructional strategies with design characteristics specific to the defined group...appears to be feasible....
- ...results were such that strong inferrences can be made regarding Aptitude Group profiles as a basis for strategy selection/development.[4]

Because Canyon Research Group analysts generally followed (though limited in resources and scope) sound ATI research principles, it is useful to quote the manner in which they constructed four alternative instructional strategies based on aptitude grouping of the student population. These strategies were subsequently found to interact positively with aptitudes in improving student terminal performance.[5]

> In the present study, a finite number of learning strengths were identified within learners and seen as representative of our target population. Strategies can be created to exploit each one of them to some degree.

The various facets of any instructional strategy are often independent characteristics which the designer must make some judgement about. One facet is that of presentation logic. Should everything be stated or should the learner be required to find things for himself or does it make any difference? Should the individual learn in a group or by himself? Should most of the materials be pictorial and in motion or with a tutor and the real world tools? Should he watch other people before he tries it? Should he be told he will be sent to Antarctica if he fails? These questions illustrate the facets of (a) Instructional sequence, (b) Peer environment, (c) Materials mode, (d) Reinforcement type. This can better be displayed in a complete mapping sentence. (See the following page.)

Some elementary arithmetic will indicate that this could require 945 discrete products which would be of little practical use.

A finite number of paths need to be selected in terms of the potential for results with the cognitive style profiles present in the population of interest.

Based on the available research in the area of design and prescription of instruction for aptitude (Allen, 1975; Cronbach and Snow,1977) strategies were developed for the aptitude profiles identified in the screening study. Table 1 displays the components of each strategy.

Strategy 1 was designed for individuals with relatively high mental ability who are field independent. These individuals benefit from self-directed instruction in which they choose their own method and pace themselves (Taylor, Montague and Hauke 1970). The learner of higher ability could be allowed to organize and manipulate symbolic meaning with a rapid rate of development in the materials (Allen, 1975). Field independent learners assume a more active role in learning, perform better under conditions of intrinsic motivation without performance feedback, and need little externally provided structure (Witkin, Moore, Goodenough and Cox, 1977; Cronbach and Snow, 1977).

Will individuals with a specific cognitive style learn more

rapidly when information is presented in an
- Inductive
- Deductive
- Learner Controlled
- Random
- Instructor Preferred

sequence in a
- Group
- Individualized
- Mixed

setting with materials presented in

a
- Visual
  - Still
  - Motion
  - Line
- Print
- Aural
  - Lecture
  - Tape
- Model
- Simulation
  - Actual
  - Mental

mode with

Reinforcement
- Intrinsic
  - Immediate
  - Spaces
- Extrinsic
  - Negative
  - Reward
  - Praise
  - Prestige
  - Competition

in a task when results are measured by a written and a performance test

TABLE 1. TABLE OF STRATEGY CHARACTERISTICS

	STRATEGY 1	STRATEGY 2	STRATEGY 3	STRATEGY4
GROUP VS. INDIVIDUAL INSTRUCTION	INDIVIDUAL	GROUP	GROUP	GROUP
PRESENTATION MODES	PRINT SIMULATOR	DIAGRAMS VISUALS	SIMULATOR SOME PRINT	LECTURE PRINT SIMULATOR
PRACTICE	MENTAL ACTUAL SELF PACED	AT END OF TRAINING	MAIN METHOD OF INSTRUCTION	LIMITED ACTUAL
MOTIVATION	INTRINSIC	EXTRINSIC PEER GROUP	EXTRINSIC COMPETITION	EXTRINSIC NEGATIVE INCENTIVES
FEEDBACK	INDIVIDUAL PROVIDES OWN FEEDBACK	IMMEDIATE AND CONTINUAL IN BOTH WRITTEN AND PRACTICE	IMMEDIATE THROUGH PRACTICE	DELAYED FEEDBACK ON TESTS IMMEDIATE ON PRACTICE
PACING	INDIVIDUAL	GROUP	GROUP	GROUP
MEDIUM	PRINT SIMULATOR	VISUAL SIMULATOR	SIMULATOR	LECTURE PRINT SIMULATOR

On the basis of the above research, the first learning strategy was designed as independent study. It included printed and visual information followed by practice (both mental and physical) when the individual decided he was ready, he was allowed to attempt the task. This strategy relied on intrinsic motivation with limited feedback.

Strategy 2 was developed for those subjects high in two-dimensional perceptual ability, and who scored high on ratings of anxiety. Gagne (1960) hypothesized that high spatial ability subjects learn from spatial presentations. Matching of figural treatments and high figural aptitude also increased retention of material (Hancock, 1975). High spatial ability subjects when given information in visual form were found to require fewer written and verbal instructions in order to process the information (Frandsen and Holder, 1969). Based on these findings, Strategy 2 relied on visually dense presentations with printed information used for attention direction.

The visuals were sequenced and progressed from single diagrams to more complex visuals. Actual practice of the task followed the visual presentations.

In dealing with learners exhibiting anxiety, Grimes and Allinsmith (1961) reported that a more structured presentation that does not rely on the individual's own resources will reduce anxiety and enhance learning. High anxiety learners have also been found to benefit from greater amounts of feedback on performance (Campeau, 1968). Strategy 2 represented structured learning materials that rely on frequent positive reinforcement and feedback concerning level of performance.

Strategy 3 was designed for low mental ability, field dependent subjects. Low aptitude learners perform best under conditions in which the instructional sequence is broken into small steps, is highly structured, and where extensive practice is provided. The instructor provided feedback and prompting (Taylor, Montague, and Hauke, 1970). The field dependent learner is

influenced by authority and peer opinion, favors interactive teaching methods, and requires extensive structuring of the learning situation (Witkin, Moore, Goodenough and Cox, 1977). Strategy 3 began with a very structured step-by-step demonstration of the task followed by practice. Necessary information was presented in small doses at a simple level.

Strategy 4 is the present mode of instruction used by the Army, and was used with the subjects that did not fit the criteria for the other 3 aptitude groups. This group represented varying combinations of the aptitudes measured, and would be comparable to a general student group. If no specific aptitudes were isolated, the present mode of instruction was deemed acceptable as a strategy considering the wide range of individual differences within the group (Parkhurst, 1975; Cronbach and Snow, 1977). This instructional strategy relied on lecture as the main method of instruction with print support materials. Limited practice in the simulator was provided as the final phase of instruction. This approach was used with the fourth aptitude group."

The results of this attempt to match aptitude groupings with instructional strategies are paraphrased on the followign page. The reader will note that all three experimental instructional strategies were developed within either the preferential model, taking advantage of high student mental abilities, or the compensatory model, which substituted structure, feedback, demonstration, and structure for high mental ability. The remedial model was not employed.

Results

- Training time for trainees to reach proficiency under alternative strategies was reduced by a factor of two measured from the base course, strategy 4.
- Response time to engage targets was decreased.
- Attitudes towards training under alternate strategies were favorable.
- Significant ATI were not demonstrated for either the written or performance tests. However, a standard, rather than a random increase, of terminal performance was evident. (Note: This lack of significant ATI may have been the result of use of a two-way ANOVA for the discriminant analysis phase of data reduction. Cronbach and Snow caution against use of the ANOVA for this reason.)
- Strategy 2 training resulted in significantly ($p > .05$) better performance on written tests than did strategies 3 or 4.
- Written test retention results indicate that strategy 3 enabled soldiers to retain their post test level of performance. Strategy 3 retention <u>improved</u> from original testing by a 10 percent mean gain.
- As with the written test no significant ATI were present for the performance test result, (use of ANOVA?). However, the following relationships were significant:

  -- Soldiers trained by strategy 3 scored significantly better on the performance test than those trained

by either strategy 2 or 4 regardless of aptitude grouping.

-- Soldiers in aptitude group 2 scored significantly better on the performance test, regardless of training strategy grouping than those who were classified as being in aptitude group 3 or 4.

Discussion

The reader will of course draw his or her own conclusions as to these results and utility of ATI to improve soldier training. Two points concerning this study, are worth raising however. First, the fact that soldiers trained by strategy 3 scored significantly better on the performance test than those trained by either strategy 2 or 4, regardless of aptitude grouping, is very interesting. Strategy 3 was developed for low aptitude learners. Hence the strategy was heavy in extensive practice, structure, feedback, etc. It may well be that psychomotor task mastery requires just this type of training to develop proficiency, much like golf or baseball. This importance of task characteristics, at least for this type of noncognitive task, on ATI is reinforced by the finding that soldiers in aptitude group 2 scored significantly better on the performance test regardless of training strategy. This strategy "was developed for those subjects high in two-dimensional perceptual ability, and who scored high on ratings of anxiety...strategy 2

relied on visually dense presentations with printed information used for attention direction."[7] And yet students in aptitude group 2 who were trained by strategy 3 (as opposed to strategy 2 developed specifically for them) scored significantly better on the performance test, regardless of ability grouping. Why? One can only speculate. However, since the REDEYE gunners tasks are perceptual and psychomotor with relatively little cognitive demand, it may well be that task characteristics were the most important variable and that instruction emphasizing these aspects was sufficient to overpower advantages inherent in other strategies more nearly matching the cognitive styles of the other aptitude groups. Secondly, it appears entirely possible that had the experiment been continued, a composite aptitude grouping combining low ability, field-dependent subjects with high spatial subjects could have been trained on an instructional strategy combining the principles of strategy 2 and 3, so as to gain additional aptitude x instructional interaction power. If this were done, and the results compared to aptitude groupings 1 and 4 and instructional strategies 1 and 4 and the original 2 and 3 aptitude/instruction mix, additional interactions might have been identified. This is a good example of the type research envisioned to take place during phase IV, data analysis, and feedback into the system.

At any rate, the approach used in this study appears very promising and, when integrated into the mature TEA process should serve to improve military training.

CHAPTER VII

CONCLUSIONS

While it is clear that the present and growing complexity of military equipment, weapon systems, and operations is such as to severely strain the Army's ability to provide adequately trained manpower, it is not clear that the service will be able to implement training programs based on individual soldier learning styles. Even though present testing and classification procedures provide much of the data needed to group trainees by cognitive aptitudes; even though the Army training system is oriented towards individual proficiency based on rigorous task analysis; and even though the educational and evaluation agencies are in place and performing needed research, it is not clear that the Army is in a position to implement fully and successfully instructional strategies based all or in part on the principles, theories, or methodologies outlined in this paper. The reasons for this are twofold: first, although great strides have been made in ATI research in the last decade, much remains to be discovered. This means that extensive, prolonged research will probably be necessary to establish a body of knowledge, techniques, and procedures that will enable the instructional developer at the TRADOC school to effectively tailor resident instruction to each new class. This is precisely what

TRASANA's TEA program is designed to do. Long term research leading to basic, fundamental changes in the manner in which instructional strategies are developed appears to be the ultimate solution. The point is that this process will take time and should not be hurried. Obviously then, the service is a long way from being able to individualize instruction in units. In fact this may never be feasible. It may prove more practicable to develop soldier skills and cognitive processes within the institution to the level where unit training can rely more on less rigidly structured individual practice of SM/SQT skills, as opposed to formal instruction more appropriate for low ability personnel. Secondly, and maybe more importantly, the Army's and TRADOC's training mission must be accomplished every day. The Army's trainers, in the school and the unit, simply do not have either the time nor the resources to experiment with unproven concepts. So the first conclusion is obvious. ATI must remain a research concept until specific, detailed procedures have been developed and validated so as to be useable within the ISD model.[1] This is not to say that ATI research should not involve natural "real world" training; it should. As mentioned previously, operational testing of developing equipment and weapons as well as basic and selected advanced individual training courses would appear to offer superb settings for the

conduct of ATI testing. It is important,however, to avoid placing the burden on organizations engaged primarily in other missions; ATI research is altogether too complex, time consuming and likely to be frustrating, to entrust to agencies that cannot devote full time to the problem. Other conclusions can be summarized as being:

- The ATI research program should be developed and conducted within the framework of the TEA process. Investigations should be integrated with ongoing instructional programs so as to ensure avaliability of adequate sample sizes (at least 100 subjects per test cell) and applicability of results to real world problems. This suggests that TRASANA should be the overall manager for Army ATI development as well as for TEA.

- Testing should be started at skill level 2 task complexity (skill level 2 refers to the SQT task listing for lower ranking soldiers, SL 3-4 delineate tasks for NCO's) to facilitate integration of the information processing model with the learning and abilities hierarchy in Chapter V, Figure 7. Testing can conceivably be scheduled for conduct with Advance Individual Training (AIT) classes for selected MOS in conjunction with TEA on fielded systems and for conduct during the pretest training prior to conduct of operational test I (OTI) for developing systems. Follow-up research can be accomplished in units and during OTI respectively, to validate treatment results by measuring levels of skill decay.

- ATI research being conducted by TRASANA should be supplemented by the efforts of the Army Research Institute For the Behavioral and Social Sciences (ARI) to develop more refined measures of general mental ability and personality variables, to include motivation constructs and attitudes. The ultimate products of this research would appear to be appropriate for inclusion in the entry level classification testing schema now represented by the ASVAB. Such inclusion would ensure availability of data Army wide and would assist Army trainers by more precise placement of soldiers into training courses for which they have appropriate aptitudes.

<u>Summary</u>

Individual differences in learning become important upon situational demand. Individuals seek to meet these demands by exploiting their mental, physical, and personality aptitudes and by compensating for a lack of aptitude. When possible, people substitute a developed aptitude for those that are underdeveloped or lacking. In the same way, instructional strategies should seek to exploit identifiable individual differences and compensate for the lack of aptitudes where necessary. The practical problem is simply to design instructional events in such a manner as to exploit or compensate for individual differences as appropriate. Research on aptitude-treatment interactions

can best be accomplished within a framework of the conduct of TEA using a multidisciplinary approach which draws on the combined skills available to ARI and TRASANA. The implementation of specific aptitude and task measures, and instructional treatment variations can and should be accomplished within the context of the present Army training system to ensure maximum coordination and to capitalize on the instructional and training skills already in being.

There is no neat, concise conclusion for this paper. It has attempted a synthesis of the present Army training system, to include in process changes represented by the TEA program, and suggests further research based on several views as to the location of the starting point. That there are other views and other starting points is indisputable--the proof however will be in the doing, in the conduct of TEA wherein a useful, coherent theory of aptitude-treatment interactions is formulated, tested and used to improve the training of the soldier.

NOTES

CHAPTER I

1. U.S. Army, The Infantry School, Study of Reading Grade Levels in the Infantry, (Ft. Benning, GA: November, 1978), p.1.

2. Ibid., p. 4-6

3. Ibid., p. 8

4. U.S. Army, Army Training Study (ARTS), Final Report, Unit Retention Testing, (Ft. Knox, KY: August, 1978), p. A-1-9.

5. Ibid., p. 3

6. Ronald Rabin, "TRADOC Training Effectiveness Analysis System", Briefing U. S. Army Training and Doctrine Command, Ft. Monroe, VA: October 1978.

7. Ibid.

8. Ibid.

CHAPTER II

1. W.J. McKeachie, "Instructional Psyscology", Annual Review of Psychology, 1974, 25, p. 161-193.

2. L.J. Cronbach and R.E. Snow, Aptitudes and Instructional Methods (New York: Irvington Publishers, Inc. 1977), p. vii.

3. Ibid.

4. Ibid., p. 6.

5. Ibid.

6. C. Carrier and B. McNergney, "Interaction Research: Can It Help Individualize Instruction?", Educational Technology, April 1979, p. 43.

7. Richard E. Snow, Theory and Method for Research on Aptitude Process, Technical Report No. 4, Stanform, CA: Office of Naval Research, June, 1977, p. 22.

8. Cronbach and Snow, p. 33.

9. Ibid.

10. Ibid., p. 13

CHAPTER III

1. U. S. Army Recruiting Command, ASVAB Counselor's Guide, U. S. Govt. Print. Off., 1977

2. U. S. Navy, Office of Naval Research, Center for Naval Analysis, Profile of a Successful Marine, (Arlington, VA, September 1977).

3. Ibid., p. 13-19

4. Ibid., p. 9

5. Ibid., p. 27

6. Ibid.

7. Ibid.

8. Ibid., p. 28.

9. Ibid., p. 25

10. U. S. Navy, Office of Naval Research, Center for Naval Analysis, An Analysis of Marine Corps School Assignment and Performance, (Arlington, VA, January 1977), p. 36.

11. Ibid., p. 37

12. Ibid.

13. U. S. Army Operational Test and Evaluation Agency (OTEA), Independent Evaluation of the Tactical Fire Direction System (TACFIRE) (U), (Falls Church, VA, Sept. 1978), p. 117.

14. F. S. Jealous, H. M. Bialek, F. Pitpit, and P. Gordon, Developing Potential of Low Ability Personnel, FR-WD (Calif) 75-6 (Presidio of Monterey, CA: HUMRRO, June 1975).

15. _Ibid._, p. 1.

16. _Ibid._, p. 28

17. _Ibid._, p. 51-55.

18. _Ibid._, p. 4.

19. _Ibid._

20. _Ibid._, p. 33

21. _Ibid._, p. 4-5

22. _Ibid._, p. 6.

23. _Ibid._, p. 35.

24. _Ibid._, p. 34.

25. _Ibid._, p. 50.

26. _Ibid._, p. 48

27. _Ibid._, p. 51

28. _Ibid._, p. 37

CHAPTER IV

1. Lee J. Cronbach and Richard E. Snow, _Aptitudes and Instructional Methods_, (New York: Irvington Publishers, Inc., 1977), p. 492.

2. Lloyd Bond and Robert Glaser, "Book Review", _Applied Psychological Measurement_, V. 3, 1 November 1979, p. 137-145.

3. _Ibid._, p. 139.

4. _Ibid._

5. Cronbach and Snow, 1977.

6. Donald E. Powers, Instructional Strategies and Individual Differences: A Selective Review and Summary of Literature, 4W10-0002, Princeton, NJ: DARPA, September 1976.

7. Cronbach and Snow, p. 492.

8. _Ibid._, p. 496-497.

9. _Ibid._, p. 498.

10. _Ibid._, p. 504.

11. _Ibid._, p. 500.

12. _Ibid._, p. 500.

13. _Ibid._, p. 502.

14. _Ibid._

15. _Ibid._, p. 501.

16. _Ibid._, p. 506.

17. _Ibid._, p. 507.

18. U. S. Navy, Office of Naval Research, Center for Naval Analysis, _Profile of a Successful Marine_,(Arlington, VA, September, 1977). p. 18

19. Cronbach and Snow, p. 507.

20. G. Domino, "Differential Predictions of Academic Achievement in Conforming and Independent Settings", _Journal of Educational Psychology_, 1968, _59_, p. 256-260.

21. Cronbach and Snow, p. 447.

22. _Ibid._, p. 410

23. U. S. Army, Army Training Study (ARTS), Final Report, Concepts of the Army Training System, (Ft. Belvoir, VA: August 1978), p. E-16.

24. Domino, p. 256-260.

25. J. M. Georgoulakis, "Why the Armor Trainee Joined", _ARMOR_, Jan-Feb 1979, _Vol. LXXXVII_, No. 1, p. 44-46.

26. Ibid., p. 46.

27. Cronbach and Snow, p. 508.

28. D. E. Hunt, et. al., Between Psychology and Education (Hinsdale, KY, Dryden, 1974).

29. Cronbach and Snow, p. 376.

30. _Ibid_., p. 376-377.

31. _Ibid_., p. 378.

32. H. A. Witkin, "The Role of Cognitive Style in Academic Performance and in Teacher-Student Relations", Unpublished report, Educational Testing Service, Princeton, NJ: 1973.

33. Cronbach and Snow, p. 382.

34. _Ibid_., p. 385.

35. _Ibid_., p. 52-53.

36. _Ibid_., p. 33.

37. _Ibid_., p. 15-60.

38. _Ibid_., p. 43.

39. Lloyd Bond and Robert Glaser, "Book Review" _Applied Psychological Measurement_, V. 3, 1 November 1979, p. 138.

40. Cronbach and Snow, p. 51-68, for a discussion concerning testing hypothesis about interactions and p. 69-106 for an analysis about advanced statistical analysis.

41. _Ibid_., p. 45-46.

42. _Ibid_.

43. U. S. Army, Army Training Study (ARTS), Final Report Concepts of the Army Training System, (Ft. Belvoir, VA: August 1978), p. SQ-4 to SQ 10.

44. Cronbach and Snow, p. 45.

45. D. J. Sullivan, et. al., _Acquisition and Retention of Cognitive versus Perceptually Oriented Training Materials_, DAHC19-77-C-0040, Westlake Village, CA: ARI, October 1978, p. 12-13.

CHAPTER V

1. D. C. Berliner and L. S. Cohen, "Trait-Treatment Interaction in Learning", Review of Research in Education, 1973, 1, p. 58-94.

2. W. J. McKeachie, "Instructional Psychology", Annual Review of Psychology, 1974, 25, p. 161-193.

3. R. Glaser, "Individuals and Learning: The New Aptitudes", Educational Researcher, 1972, 7 (6), p. 5-13.

4. E. Hunt, et. al., Individual Differences in Cognition: A New Approach to Intelligence, G. H. Bower, ed., The Psychology of Learning and Motivation, V. 7, (New York: Academic Press, 1973).

5. Richard E. Snow, Theory and Method for Research on Aptitude Processes: A Prospectus, Technical Report No. 2 (Stanford, CA: Office of Naval Research, June 1977), p. 3-5.

6. Ibid., p. 6.

7. Ibid., p. 7-8.

8. Ibid., p. 10

9. Snow, p. 14.

10. Ibid., p. 16

11. L. J. Cronbach and R. E. Snow, Aptitudes and Instructional Methods, (New York: Irvington Publishers, Inc., 1977), p. 113-115.

12. R. M. Gagne, "Learning Hierarchies", Educational Psychologist, 1968, 6, p. 1-9.

13. Snow, p. 16-17.

14. Ibid., p. 17.

15. Ibid., p. 18.

16. G. H. Bower, Cognitive Psychology: An Introduction. W. K. Estes, ed., Handbook of Learning and Cognitive Process, Vol, I, (Hillsdale, NJ: Erlbaum 1975).

17. Snow, p. 20-29.

18. *Ibid.*, p. 26

19. *Ibid.*, p. 29-30.

20. *Ibid.*

21. *Ibid.*

22. Cronbach and Snow, p. 170-171.

23. F. J. DiVesta, "Theory and Measures of Individual Differences in Studies of Trait by Treatment Interaction", *Educational Psychologist*, 1973, 13 (1), p. 5-12.

24. K. R. Shapiro, "An Overview of Problems Encountered in Aptitude Treatment Interaction (ATI) Research for Communication", *AV Communication Review*, 1973, 23(2), p. 227-241.

25. R. M. Gagne, "Task Analysis: Its Relation To Content Analysis", *Educational Psychologist*, 1973, 11 p. 11-18.

26. Cronbach and Snow p. 393-480.

27. U. S. Army, Training and Doctrine Command (TRADOC), *Pamphlet 350-30, Interservice Procedures for Instructional Development*, Executive Summary, N. D.: 1 August 1975, p.21-25.

28. Snow, p. 32

29. *Ibid.*, p. 32-33.

30. *Ibid.*, p. 33

CHAPTER VI

1. L. J. Cronbach and R. E. Snow, *Aptitudes and Instructional Methods*, (New York: Irvington Publishers, Inc., 1977) p. 61-98.

2. *Ibid.*, p. 53-61

3. D. J. Sullivan, et. al., *Acquisition and Retention of Cognitive versus Perceptually Oriented Training Materials*, DAHC19-77-C-0040, Westlake Village, CA: ARI, October 1978, p. 1.

4. *Ibid.*, p. 5-6.

5. *Ibid.*, p. 21-25.

6. *Ibid.*, p. 40-42.

7. *Ibid.*, p. 20.

CHAPTER VII

1. U. S. Army, Training and Doctrine Command (TRADOC), *Pamphlet 350-30, Interservice Procedures for Instructional Development*, Executive Summary, N. D.: 1 August 1975, p. 11.

APPENDIX I

1. U. S. Dept. of Defense, Headquarters, Military Enlistment Processing Command, (U. S. Govt. Print. Off., 1 July 1976).

2. U. S. Army, Behavior and Systems Research Laboratory, *An Improved Differential Army Classification System*, Technical Report 1177, April 1972, p. 11-12.

APPENDIX II

1. U. S. Navy, Office of Naval Research, *Theory and Method for Research on Aptitude Processes: A Prospectus*, (Arlington, VA, Oct. 1976), p. 6-7.

BIBLIOGRAPHY

Allen, W.H. "Intellectual Abilities and Instructional Media Design." AV Communications Review, 23, 1975, p. 139-170.

Atkinson, R.C. "Ingredients for a Theory of Destruction." American Psychologist, 27, 1972, p. 921-931.

Berlines, D.C. and Cohen, L.S. "Trait Treatment Interactions in Learning." Review of Research in Education, 1, 1973, p. 58-94.

Bigelow, G.S. and Egbert, R.L. "Personality Factors and Independent Study." Journal of Educational Research, 62, 1968, p. 37-39.

Bond, L. and Glasner, R. "Book Review of Aptitudes and Instructional Methods." Applied Psychological Measurement, V. 3, No. 1, 1979, p. 137-140.

Borman, W.C. and Bleda, P.R. Measuring Motivation and Job Satisfaction in a Military Context. Alexandria, Va.: ARI, September 1978.

Bower, G.H., ed. The Psychology of Learning and Motivation. New York: Academic Press, 1973.

Bunderson, C.V. "Ability by Treatment Interactions in Designing Instructions for a Hierarchial Learning Task." Lecture, American Educational Resources Association, Los Angeles, CA.: February 1969.

Bush, R.R. and Lovejoy, E.P. "Learning to Criterion: A Study of Individual Differences." Lecture, Stanford University, 1965.

CAMPEAV, P.L., "Test Anxiety and Feedbacks in Programmed Instructions." Journal of Educational Psychology, 59, 1968, p. 159-163.

Caron, A.J. "Curiosity, Achievement, and Avoidant Motivation as Determinants of Epistimic Behavior." Journal of Abnormal and Social Psychology, 67, 1963, p. 535-733.

Carrier, C. and McNergney, R. "Interaction Research: Can It Help Individualize Instruction?" Educational Technology, April 1979, p. 40-45.

Cattell, R.B. Abilities: Their Structure, Growth and Actions. Boston: Houghton-Mifflin, 1971.

Cronbach, L.J., et al. Aptitudes and Instructional Methods. New York: Irvington, 1977.

Cronbach, L.J. Essentials of Psychological Testing. 3d ed. New York: Harper, 1970.

Dansireau, Donald F., Long, Gary L., McDonald, Barbara A., and Actkinson. Learning Strategy Inventory Development and Assessment. AFHRL-TR-75-40. Texas Christian University: Air Force Systems Command, June 1975.

________. Learning Strategies: A Review and Synthesis of the Literature. AFHRL-TR-74-70. Texas Christian University: Air Force Systems Command December 1974.

Davis, R.H., Marzocci, F.N. and Denny, M.R. "Interaction or Individual Differences with Modes of Presenting Programmed Instruction." Journal of Educational Psychology, V. 61, No. 3, 1970, p. 198-204.

Doty, Barbara A. "Teaching Method Effectiveness in Relation to Certain Student Characteristics." The Journal of Educational Research, V. 60, No. 8, April 1967.

Domino, G. "Differential Predictions of Academic Achievement in Conforming and Independent Settings." Journal of Educational Psychology, V. 59, p. 256-260.

Estes, W.K., ed. Handbook of Learning and Cognitive Processes Hillsdale, N.J.: Erlboum, 1975.

Eysenck, H.J. "Intelligence Assessment: A Theoretical and Experimental Approach." British Journal of Educational Psychology, 5, p. 403-411.

Frandsen, A.N. et al. "Spatial Visualization in Solving Complex Verbal Problems." The Journal of Psychology, V. 73, 1969, p. 229-233.

Fry, J.P. "Interactive Relationship Between Inquisitiveness and Student Control of Instruction." Journal of Educational Psychology, 63, p. 459-465.

Gagne, R.M. "Ability Differences in the Learning of Concepts Governing Directed Numbers in Research Problems and Mathematics Education." Cooperative Research Monograph, No. 3, 1960, p. 112-113.

Gagne, R.M., ed. Learning and Individual Differences. Columbus, Ohio: Menil, 1967.

________. "Learning Hierarchies." Educational Psychologist, V. 6, 1968, p. 1-9.

Georgovlakis, J.M. "Why the Armor Trainee Joined." Armor, V. LXXXVIII, No. 1, p. 44-46.

Glaser, R. "Components of Psychology of Instruction: Toward a Science of Design." Review of Educational Research, V. 46, p. 1-24.

________. "Individuals and Learning: The New Aptitudes." Educational Researcher, 7(6), 1972, p. 5-13.

Goodeneough, D.R. "The Role of Individual Differences in Field Dependence as a Factor in Learning and Memory." Psychological Bulletin, 83, 1976, p. 675-694.

Greeno, J.G. "Theory of Language Processing." Lecture, Annual Meeting of American Association of the Advancement of Science, Denver, Co.: 22 February 1977.

Grimes, J.W. and Allinsmith, A.W. "Compulsivity and School Achievement." Menill-Palmer Quarterly, 7, 1961, p. 247-271.

Guilford, L. et al. The Analysis of Intelligence. New York: McGraw-Hill, 1971.

Guttman, L. "The Structure of Relations Among Intelligence Tests." Proceedings, 1964 Invitational Conference on Testing Problems. Princeton, N.J.: 1965.

Hancock, R.R. "Cognitive Factors and their Interaction with Instructional Mode." Journal for Research in Mathematical Education, 6, 1975, p. 12-16.

Hunt, D.E., et al. Between Psychology and Education. Hinsdale, Il.: Dryden, 1974.

Hunt, D.E. Matching Models in Education: The Coordination of Teaching Methods with Student Characteristics. Toronto: Ontario Institute for Studies in Education, 1971.

Hunt, E., et al. "Individual Differences in Cognition: A New Approach to Intelligence." Bower, ed. The Psychology of Learning and Motivation. (New York: Academic Press, 1973, V. 7.)

Hunt, E.B. "Verbal IQ and Information Processing." Lecture, Annual Meeting of American Association for the Advancement of Science, Denver, Co.: 22 February 1977.

Interview with Dr. P. Deason, TRADOC Systems Analysis Activity, White Sands Missile Range, N.M.: 18 May 1979.

Interview with Dr. B. Fan, U.S. Army Research Institute for the Behavioral and Social Sciences, Alexandria, Va.: 18 April 1979.

Interview with Dr. M. Farr, Office of Naval Research, Arlington, Va.: 17 April 1979.

Jealous, F., et al. Developing Potential of Low Ability Personnel, FR-WD (Calif) 75-6 (Presidio of Monterey, Ca.: Humrro, June 1975.

Interview with Dr. John Lockhart, U.S. Army Research Institute for the Behavioral and Social Sciences, Ft. Bliss Field Office, Ft. Bliss, TX.: 17 May 1979.

Interview with Dr. L. Neal, TRADOC Systems Analysis Activity, White Sands Missile Range, NM.: 18 May 1979.

Interview with Dr. Milton Maier, U.S. Army Research Institute for the Behavioral and Social Sciences, Alexandria, VA.: 18 April 1979.

Interview with Col. R. Rabin, TRADOC Systems Analysis Activity, White Sands Missile Range, NM.: 18 May 1979.

Jensen, A.R. Educability and Group Differences. New York: Harper and Row, 1973.

Marshal, H.H. "Learning as a Function of Tasks Interest, and Social Class Variables." Journal of Educational Psychology. V. 60, No. 2, 1970, p. 133-137.

McKeachie, W.J. "Instructional Psychology." Annual Review of Psychology, 25, 1974, p. 161-193.

Michael, W.B., Guilford, J.P., Fruchter, B. and Zimmermon, W.S. "The Description of Spatial Visualization Abilities." Educational and Psychological Measurement, 17, 1957, p. 185-199.

Newell, A. and Simon, H.A. Human Problem Solving. Englewood Cliffs, N.J.: Prentice Hall, 1972.

Norman, Donald A. "Teaching Learning Strategies". Resources in Education, Vol. 13, No. 8, August 1978, p. 28.

Nuthall, G. "An Experimental Comparison of Alternative Strategies for Teaching Concepts." American Educational Research Journal, 5, 1968, p. 561-584.

Parlshurst, P.E. "Generating Meaningful Hypothesis with Aptitude - Treatment Interactions." AV Communications Review, 1975, 23, p. 171-182.

Peterson, P.L. "Interactive Effects of Student Anxiety, Achievement Orientation, and Teacher Behavior on Student Achievement and Attitude." Unpublished Doctoral Dissertation. Stanford: 1976.

Powers, Donald E. Instructional Strategies and Individual Differences: A Selective Review and Summary of Literature. 4W10-0002. Princeton, N.J.: Darpa, September 1976.

Rabin, Ronald. "TRADOC Training Effectiveness Analysis System." Briefing, U.S. Army Training and Doctrine Command, Ft. Monroe, VA.: October 1978,

Resnick, L., ed. The Nature of Intelligence. Hillsdale, NJ.: Erlbaum, 1976.

Ripple, R.R., Millman, J., and Glock, M.D. "Learner Characteristics and Instructional Mode: A Search for Disordinal Interactions." Journal of Educational Psychology, V. 60, No. 2, 1970, p. 113-120.

Rosenberg, H., Mintz, S. and Clark, R.E. "The Educational Significance of Field Dependence Research." Educational Technology, 1977, p. 43-44.

Salomon, G. "Can We Effect Cognitive Skills Through Visual Media? An Hypothesis and Initial Findings." AV Communication Review, 20(4), 1972, p. 401-422.

________. "Heuristic Models for the Generation of Aptitude Treatment Interaction Hypotheses." Review of Educational Research, 42, 1972, p. 327-343.

________. "Internalization of Filmic Operations in Relation to Individual Differences." Journal of Education Psychology, 66, p. 499-511.

Shaw, James B. and McCormick, Ernest J. The Prediction of Job Ability Requirements Using Attribute Data Based Upon the Position Analysis Questionnaire, NR 150-872. Purdue University: Office of Naval Research, October 1976.

Sinclair, K.E. "The Influence of Anxiety on Several Measures of Classroom Performance." Australian Journal of Education, 13, 1969, p. 296-307.

Simon, H.A. "Identifying Basic Abilities Underlying Intelligence Performance of Complex Tasks." In L.B. Resnicks (ed.) The Nature of Human Intelligence, Hillsdale, N.J.: Erlbaum, 1976.

Skanes, G.R., Sullivan, A.M., Rowe, E.J. and Shannon, E. "Intelligence and Transfer: Aptitude by Treatment Interactions." Journal of Educational Psychology, V. 66, No. 4, 1974, p. 563-568.

Snow, R.E. Individual Differences, Instructional Theory, and Instructional Design. Tech Report No. 4. Stanford, CA.: Office of Naval Research, June 1977

________. Theory and Method for Research on Aptitude Process: A Prospective. Tech Report No. 2, Stanford, CA.: Office of Naval Research, October 1976.

Sternberg, R.J. Intelligence Information Processing, and Analogical Reasoning: The Componential Analysis of Human Abilities. Hillsdale, N.J.: Erlbaum, 19__

Sullivan, Dennis J., Casey, Robert J., Hebein, Jeanne M. Acquisition and Retention of Cognitive Versus Perceptably Oriented Training Materials. DAH C19-77-C-0040. Westlake Village, CA.: ARI, October 1978.

Szetala, E. "The Effects of Test Anxiety and Success/Failure on Mathematics Performance in Grade Eight." Journal for Research in Mathematics Education, 46, 1973, p. 152-160.

Tallmadge, G.K. and Shearer, J.W. "Interactive Relationships Among Learner Characteristics, Types of Learning, Instructional Methods, and Subject Matter Variables." Journal of Educational Psychology, V. 62, No. 1, 1971, p. 31-38

________. "Relationships Among Learning Styles, Instructional Methods, and the Nature of Learning Experiences." Journal of Educational Psychology, V. 66, No. 3, 1969, p. 222-230.

Taylor, J.E., Montague, E.K. and Hauke, R. The Interrelationships of Ability Level, Instructional Systems, and Skill Acquisition. Symposium Presentation at the American Psychological Association Convention, Miami Beach, September 1970.

U.S. Air Force. Human Resources Laboratory, Air Force Systems Command. Effective Learning Strategy Training Program: Development and Assessment. Brooks Air Force Base, TX.: June 1975.

________. Learning Strategy Training Program: Paraphrasing Strategy for Effective Learning. Brooks Air Force Base, TX.: June 1975.

U.S. Army. Behavior and Systems Research Laboratory. An Improved Differential Army Classification System. Arlington, VA.: April 1972.

U.S. Army. Operational Test and Evaluation Agency. Independent Evaluation of the Tactical Fire Direction System (TAC FIRE) (U). Falls Church, VA.: September 1978.

U.S. Army Recruiting Command. ASVAB Counselor's Guide. U.S. Government Printing Office, 1977.

U.S. Army. Army Training Study (ARTS). Final Report. Ft. Belvoir, VA.: August 1978.

U.S. Army. Training and Doctrine Command (TRADOC). Pamphlet 350-30, Interservice Procedures for Instructional Development. n.p.: 1 August 1975.

U.S. Army. TRADOC Systems Analysis Activity. REDEYE Weapons System (2 Vol) Training Effectiveness Analysis. White Sands Missile Range, N.M.: August 1978.

U.S. Army. The Infantry School. Study of Reading Grade Levels in the Infantry. Ft. Benning, GA.: November 1978.

U.S. Department of Defense. Armed Force Vocational Testing Group. Reference Tables for the Armed Services Vocational Aptitude Battery. Randolph Air Force Base, TX.: 11 March 1974.

U.S. Military Enlistment Processing Command. Representative Normative Tables for the Armed Services Vocational Aptitude Battery (Form 5). Ft. Sheridan, IL.: September 1976.

U.S. Navy. Office of Naval Research. Center for Naval Analysis. An Analysis of Marine Corps School Assignment and Performance. Arlington, VA.: January 1977.

U.S. Naval War College. Center for Advanced Research. An Analysis of Marine Corps Training. Newport, R.I.: June 1978.

U.S. Navy. Office of Naval Research. Center for Naval Analyses. Profile of a Successful Marine. Arlington, VA.: September 1977.

U.S. Navy. Office of Naval Research. Some Personality Correlates of Perceptions of and Reactions to Task Characteristics. Arlington, VA.: 11 March 1977.

U.S. Naval War College. Center for Advanced Research. Behavioral Objectives: The Dilemma of Empirical Adequacy. Newport, R.I.: June 1978.

Vernon, P.E. The Structure of Human Abilities. London: Methuen, 1951.

Witkin, H.A., Moore, C.A., Goodenough, D.R., and Cox, P.W. "Field-Dependent and Field-Independent Cognitive Styles and their Educational Implications." Review of Educational Research, 47, 1977, p. 1-64.

Witkin, H.A. "The Role of Cognitive Style in Academic Performance and in Teacher-Student Relations." Unpublished Report. Educational Testing Service, Princton, N.J.: 1973.

APPENDIX I

SUMMARY DISCUSSION OF APTITUDE AREA COMPOSITES

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SUMMARY DISCUSSION OF APTITUDE AREA COMPOSITES

The purpose of this appendix is to provide a summary discussion of the Armed Services Vocational Aptitude Battery (ASVAB) of tests and the composite aptitude areas that are used for classification and assignment purposes within the Army.

The appendix is in two parts. Part I is a general discussion as to the evolution of the ASVAB and the ASVAB 5, High School aptitude area composites, to familiarize the reader with the type and extent of aptitude measuring used by the armed forces today.[1] This information can be contrasted with the type and scope of aptitude measurement deemed necessary to support ATI research and curriculum development. Part II is a summary discussion of the aptitudes required for classification into the various Army Career Management Fields (CMF) and the tests used to measure these aptitudes.[2]

PART I ASVAB DEVELOPMENT

In 1966, the military services drew upon 25 years of experience in aptitude testing to begin development of a vocational aptitude battery which could be used in high school counseling programs. The new battery was designed to measure a student's aptitudes for specific types of

job training. In 1968, the ASVAB was administered in high schools for the first time.

By 1974, the ASVAB had demonstrated its value as a potential replacement for several personnel selection/ classification tests then in use by the military services. Accordingly, the content of the ASVAB was expanded from 9 to 12 tests; and, on January 1, 1976, its use throughout the Department of Defense was instituted. Since the beginning of school year 1976-1977, the ASVAB has been admin tered to high school students and military applicants alike within the United States and its territories.

A summary of the ASVAB forms and their use is shown in Table 1.

TABLE 1

FORMS OF THE ARMED SERVICES
VOCATIONAL APTITUDE BATTERY (ASVAB)

Form No.	Use
ASVAB-1	High School Testing Program (SY 1973/74 and earlier)
ASVAB-2	High School Testing Program (SY's 1974/75 and 1975/76)
ASVAB-3	Air Force and Marine Corps Selection and Classification Test
ASVAB-4	Back-up to ASVAB-2 (never released)
ASVAB-5	High School Testing Program beginning July 1976
ASVAB-6/7	All Services Selection and Classification Test Beginning January 1976

TABLE 2

CONTENT -- FORM 5 OF ASVAB*

Test	Number of Items
General Information (GI)	15
Numerical Operations (NO)	50
Attention to Detail (AD)	30
Word Knowledge (WK)	30
Arithmetic Reasoning (AR)	20
Space Perception (SP)	20
Mathematics Knowledge (MK)	20
Electronics Information (EI)	30
Mechanical Comprehension (MC)	20
General Science (GS)	20
Shop Information (SI)	20
Automotive Information (AI)	20
Totals	295

Summary Discussion of ASVAB Test Measures

GENERAL INFORMATION (GI)--Measures a portion of a student's developed ability to recognize factual information characterized by the cumulative influences of his or her learning experiences.

NUMERICAL OPERATIONS (NO)--Measures an individual's developed ability to rapidly and accurately compute simple number computations.

ATTENTION TO DETAIL (AD)--Designed to measure the ability of an individual to perceive simple relationships, to retain these relationthips mentally, and to make decisions based upon the relationships involved quickly and accurately.

WORD KNOWLEDGE (WK)--Measures verbal comprehension which entails the ability to understand written and spoken language.

* Note ASVAB 6 and 7 are parallel forms of ASVAB 5 Adminstered at the Armed Forces entrance and examining station.

ARITHMETIC REASONING (AR)--Designed to measure general reasoning. It is concerned with the ability to generate solutions to problems. It is different from Numerical Operations in that the student must construct a solution by some principle in order to solve the given problem.

SPACE PERCEPTION (SP)--Measures an individual's spatial aptitude. This infers an ability of an individual to visualize and manipulate objects in space.

MATHEMATICS KNOWLEDGE (MK)--Measures functional ability in the use of learned mathematical relationships. Factors measured by this area tend to overlap the areas of numerical operations and arithmetic reasoning. The similarities are in the functions performed. The differences lie in the complexities of the functions.

ELECTRONIC INFORMATION (EI)--Measures functional ability in the use of learned electronic relationships. A number of factors appear to be measured by this test: arithmetic reasoning in the form of simple electronic calculations; verbal comprehension in terms of the person's reading level with respect to electronic terminology; and a level of general reasoning is indicated by having the individual make use of electronic principles in order to arrive at the correct answer.

MECHANICAL COMPREHENSION (MC)--Measures the ability of an individual to learn, comprehend, and reason with mechanical terms. Even though familiarity with common tools and mechanical relations is a prerequisite, further technical knowledge is not necessary other than that acquired through day-to-day experiences. This test has pictures of mechanisms whose functions call for comprehension.

GENERAL SCIENCE (GS)--Measures a level of verbal comprehension in the general area of science. This test was designed to measure a form of reasoning which involves the ability to see the relationship between two factors or scientific ideas. Some arithmetic reasoning may also be involved.

SHOP INFORMATION (SI)--Measures the functional ability of an individual who has had experience with and is knowledgeable about the use of a variety of tools found in a shop. In addition, it appears that a level of verbal comprehension is also measured as indicated by the understanding needed of the terminology used.

AUTOMOTIVE INFORMATION (AI)--Measures the functional ability of an individual who has had some experience working with automobiles. This test also relies upon an individual's reading ability and verbal comprehension. The questions may pertain to diagnosing malfunctions of a car, the use of a particular part(s) of a car, or meaning of terminology.

The scores on the ASVAB are used to construct aptitude composites in five human ability areas as well as to provide an indication of academic ability. These composites are not intended to provide the student with job-specific information, but rather to encourage students to make further exploration into their own abilities. Scores on the ASVAB test are combined to form the composite scores as follows:

DEFINITION OF ASVAB COMPOSITES

VERBAL (VE). Measures knowledge of words, ability to understand written materials, and to deal with verbal concepts. The composite is a combination of the scores on the Word Knowledge, General Information, and General Science tests.

ANALYTIC/QUANTITATIVE (AQ). Measures reasoning abilities as well as those relevant to understanding quantitative concepts. The composite is a combination of the scores on the Arithmetic Reasoning and Mathematics Knowledge tests.

CLERICAL (CL). Measures speed and accuracy in using letters and numbers. These are abilities relevant to clerical type activities. The composite is a combination of the scores on the Attention to Detail and Numerical Operations tests.

MECHANICAL (ME). Measures understanding of mechanical principles as well as the ability to visualize objects in three-dimensional space. The composite is a combination of the scores on the Space Perception and Mechanical Comprehension tests.

TRADE TECHNICAL (TT). Measures information relevant to automotive and various shop practices. The composite is a combination of the scores on the Automotive Information and Shop Information tests.

ACADEMIC ABILITY (AA). Measures abilities needed to do well in school and formal types of training. The composite is a combination of the scores on the Word Knowledge and Arithmetic Reasoning tests.

PART II

Aptitude Area Composites for the Active Army differ from those used in the high school, even though they are based on the same tests. Army aptitude area composites are as shown in Table 3 below:

TABLE 3

APTITUDE AREA COMPOSITES

CO = Combat	MM = Mechanical Maintenance
FA = Field Artillery	GM = General Maintenance
EL = Electronics Repair	CL = Clerical
OF = Operators and Food	ST = Skilled Technical
SC = Surveillance and Communications	

The scores on the ASVAB are used to measure aptitudes as listed below. In addition, soldiers are also adminstered the Army classification inventory which determined their specific areas of interest.

The Combat (CO) Aptitude Area test a complex combination of aptitudes. The good combat soldier needs general ability, measured by the Arithmetic Reasoning Test. He needs mechanical ability, measured by the Trade Information

Test, to handle his weapons and equipment. Perceptual ability is important--he has to orient himself in the terrain and observe his environment. This capability is measured by the Pattern Analysis and Attention-to-Detail tests. Finally, an interest in outdoor masculine activities, coupled with self-confidence, is associated with good combat performance. The Combat (CC) scale of the Classification Inventory yields a measure of this interest.

The artilleryman, in comparison, requires more mathematical ability. Therefore, scores from both the Arithmetic Reasoning Test and the Mathematics Knowledge Test enter into the Field Artillery (FA) Aptitude Area. A further measure of general ability is contributed by the General Information Test. Mechanical ability, measured by the Electronics Information Test, and an interest in details, measured by the Attentiveness (CA) scale of the Classification Inventory, complete the picture for the artilleryman.

Jobs for which the Electronics (EL) aptitude area is designated as selector require some general ability (Arithmetic Reasoning), a heavy concentration of mechanical ability (Electronics Information, Shop Mechanics, and Mechanical Comprehension), and an interest in electronics, measured by the Electronics (CE) scale of the Classification Inventory.

Operators and Food (OF), the aptitude area for the selection of operators of vehicles and missile equipment

and food handler personnel, resulted as one of the simplest composites. The General Information and Automotive Information tests and the Attentiveness (CA) scale of the Classification Inventory represent a combination of requirements applying to this group of MOS.

Components of the Surveillance and Communications (SC) Aptitude Area include general ability, represented by the Arithmetic Reasoning and Word Knowledge tests, mechanical ability, measured by the Mechanical Comprehension Test, and perceptual ability, measured by the Pattern Analysis and Auditory Perception tests. Inclusion of general ability and perceptual skills in the aptitude area is consistent with the tasks of information acquisition, processing, and transmission common to the MOS in the group.

Two areas involve maintenance primarily--mechanical and general. The MOS for which the Mechanical Maintenance (MM) Aptitude Area is a selector require heavy concentration of mechanical ability, measured by the Automotive Information, Electronics Information, and Trade Information tests, plus mathematics ability (Mathematics Knowledge) and an interest in mechanics, measured by the Maintenance (CM) scale of the Classification Inventory. The General Maintenance (GM) Aptitude Area reflects a heavier requirement for general ability, measured by the Arithmetic Reasoning and Science Knowledge tests. The mechanical

requirements are less than for the mechanical maintenance MOS, and only the Mechanical Comprehension and Automotive Information test are included. These differences are consistent with the MOS areas for which these aptitude areas are used. The mechanical maintenance MOS are almost entirely concerned with motors and equipment, while the general maintenance MOS cover operators and more specialized repair work.

In the Clerical (CL) Aptitude Area, the general ability requirement for jobs is measured by the Arithmetic Reasoning and Word Knowledge tests. Perceptual speed is covered by the Attention-to-Detail Test, and pertinent interest in detail by the Attentiveness (CA) scale of the Classification Inventory.

The MOS in the skilled technical group are generally the most technical and academically oriented of all the enlisted MOS. The Skilled Technical (ST) Aptitude Area therefore consists entirely of tests in the general ability domain--Arithmetic Reasoning, Mathematics Knowledge, and Science Knowledge.

A final composite is the familiar General Technical (GT) Aptitude Area, composed of the Arithmetic Reasoning and Word Knowledge (Verbal) tests. In the old system, the GT score is used both to select men for general technical MOS and to determine which men are eligible to take

additional tests such as the Officer Candidate Test. In the new system, the function of selector for MOS group is shifted to the ST composite. The function of determining eligibility for additional testing continues to be filled by the combination of Arithmetic Reasoning and Word Knowledge tests. The label GT is retained.

Unit weights for the tests entering into the composite scores were decided upon following evaluation of several weighting schemes to determine their effect on the total effectiveness of the aptitude area structure in predicting soldier performance. A full account of the evaluation research is presented in BESRL Technical Research Note 239.*

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* Maier, Milton H. and Edmund F. Fuchs."Development and Evaluation of a New ACB and Aptitude Area System." Technical Research Note 239. Behavior and Systems Research Laboratory, Arlington, VA. February 1972.

APPENDIX II

A COMPILATION OF DEFINITIONS OF MAJOR HUMAN MENTAL ABILITIES

APPENDIX II

A COMPILATION OF DEFINITIONS OF MAJOR HUMAN MENTAL ABILITIES*

The purpose of this Appendix is to provide the reader with a compilation of definitions to be used in conjunction with Figure 6.[1]

General Mental Ability (G)

Binet (in Terman, 1916, p. 45)	"The tendency to take and maintain a definite direction; the capacity to make adaptations for the purpose of attaining a desired end; and the power of auto-criticism."
Binet and Simon (1916, pp. 42-43)	"... judgement, otherwise called good sense, practical sense, initiative, the faculty of adapting one's self to circumstances. To judge well, to comprehend well, to reason well, these are the essential activities of intell-igence."
Spearman (1923)	"... everything intellectual can be reduced to some special case...of educing either relations or corre-lates." (p. 300) Eduction of rela-tions--"The mentally presenting of any two or more characters...tends to evoke immediately a knowing of relation between them." (p. 63) Eduction of correlates--"The presenting of any character together with any relation tends to evoke immediately a knowing of the correlative character." (p. 91)

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* Source: Snow, R.E., Theory and Method for Research on Aptitude Processes: A Prospectus, OFC of Naval Research Arlington, VA. Oct 1976. p.

Stoddard (1943, p. 4)	"...the ability to undertake activities that are characterized by (1) difficulty, (2) complexity, (3) abstractness, (4) economy, (5) adaptiveness to a goal, (6) social value, and (7) the emergence of originals, and to maintain such activities under conditions that demand a concentration of energy and a resistance to emotional forces."
Freeman (1955, pp. 60-61)	"...adjustment or adaptation of the individual to his total environment, or to limited aspects thereof. ... the capacity to reorganize one's behavior patterns so as to act more effectively and more appropriately in novel situations. "... the ability to learn. ...the extent to which (a person) is educable. "... the ability to carry on abstract thinking... the effective use of concepts and symbols in dealing with...a problem to be solved."
J. McV. Hunt (1961, p.362)	"...conceived as intellectual capacities based on central processes hierarchically arranged within the intrinsic portions of the cerebrum. These central processes are approximately analogous to the strategies for information processing and action with which electronic computers are programmed."
Jenson (1969, p.9)	"When the term 'intelligence' is used it should refer to (Spearman's) *g*, the factor common to all tests of complex problem-solving"
(1970. pp.147-148)	"...mental tests can be ordered along a continuum going from simple to complex. ...The intercorrelations among tests are roughly related to their degree of proximity on the complexity continuum, and tests which are intended to identify *g*... show increasing correlations with other tasks as one moves along the continuum from simple to complex."

Crystallized Ability (G_c)

Cattel (1963, p. 2)	"Crystallized ability loads more highly those cognitive performances in which skilled judgement habits have become crystallized (whence it's name) as the result of earlier learning application of some prior more fundamental ability in these fields. Thurstone's Verbal and Numerical primaries, or achievement in geography or history, would be examples of such products."
Horn (1976, p. 455)	"Awareness of concepts and terms pertaining to a broad variety of topics, as measured in general information and vocabulary tests and in tests which measure knowledge in science, mechancis, social studies, English literature mathematics, and a variety of other areas. It is also manifested in the Information, Vocabulary, Comprehension, Similarities and, to a lesser extent, Arithmetic subtests of the Wechsler Scales... . In much of the British' work it is labeled verbel-educational (v:ed) intelligence."

Fluid-Analytic Ability (G_f)

Cattell (1963, p. 3)	Fluid general ability, on the other hand, shows more in tests requiring adaptation to new situations, where crystallized skills are of no particular advantage."
Horn (1976, p. 445)	"Facility in reasoning, particularly in figural and non-word symbolic materials, as indicated in tests such as letter series, matrices, mazes, figure classifications, and word groupings, as well as the block designs, picture arrangements, object assembly, and picture completion subtests of the Wechsler Scales... . Some characterize it as non-verbal intelligence (although verbal tests can measure it) or performance IQ. In the British work it is known as spatial-perceptual-practical intelligence (k:m)."

Visualization Ability (G_v)

Horn (1976, p. 448)	"When analyses pertain to concepts more general than the primary abilities, the various spatial tasks... (involving ability to perceive and transform images of spatial patterns, maintaining orientation in spatial arrangements) tend to hang together in what can be referred to as a general visualization dimension which seems to be as least somewhat distinct from G_f, and is clearly distinct from G_c...."